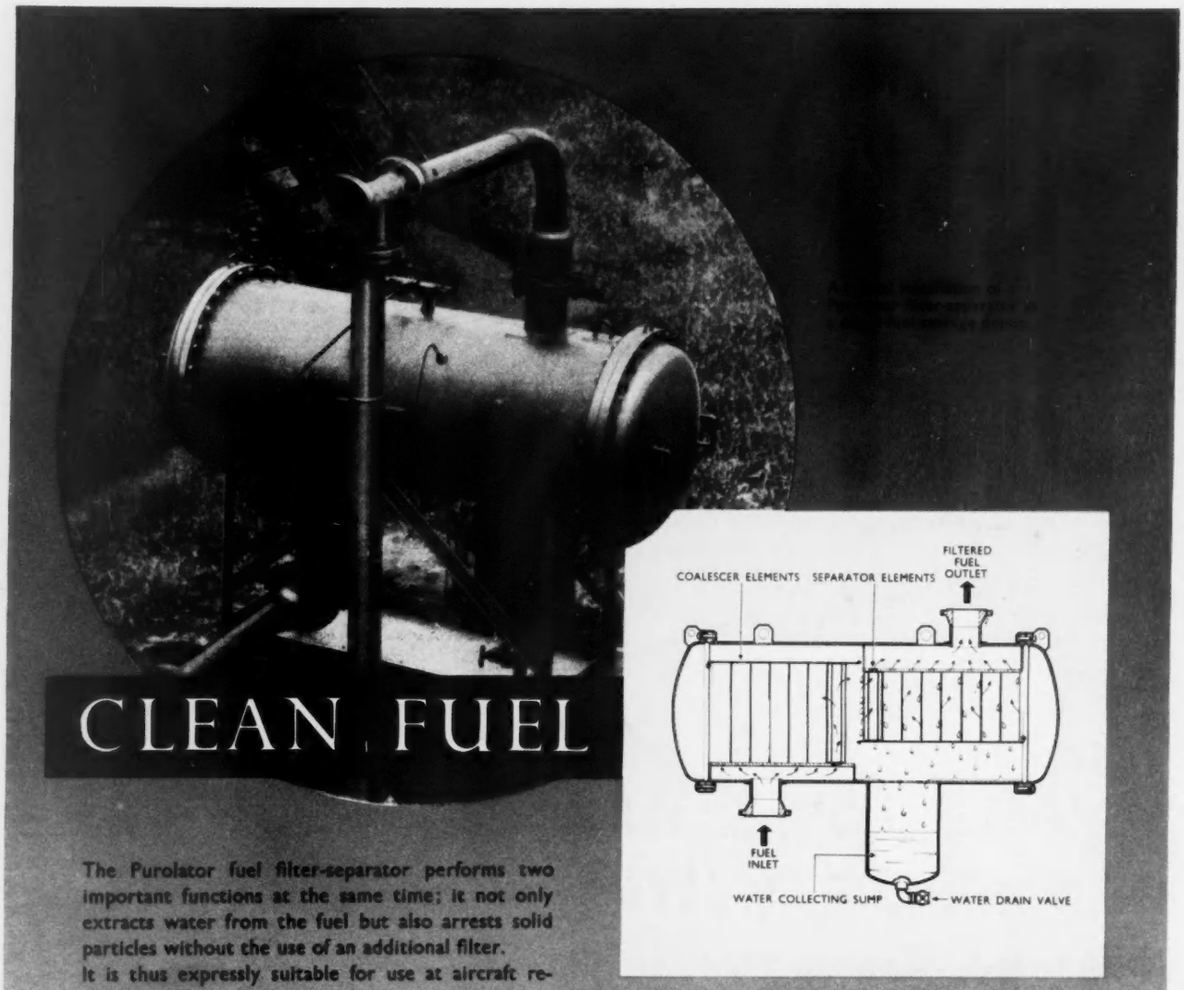
The Engineer

OCTOBER 10, 1958 28 ESSEX ST., STRAND, LONDON, W.C.2 TWO SHILLINGS



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It is thus expressly suitable for use at aircraft re-fuelling stations, in diesel fuel storage depots, large test houses for engines, for dockside installations, and in fact wherever liquid fuel is handled in bulk.

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As can be seen from the diagram and photograph, outstanding features of the design are its compactness and simplicity. A range of models suitable for flow rates up to 750 G.P.M. is immediately available and larger sizes can be built if required.

REMOVES DIRT

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REMOVES WATER

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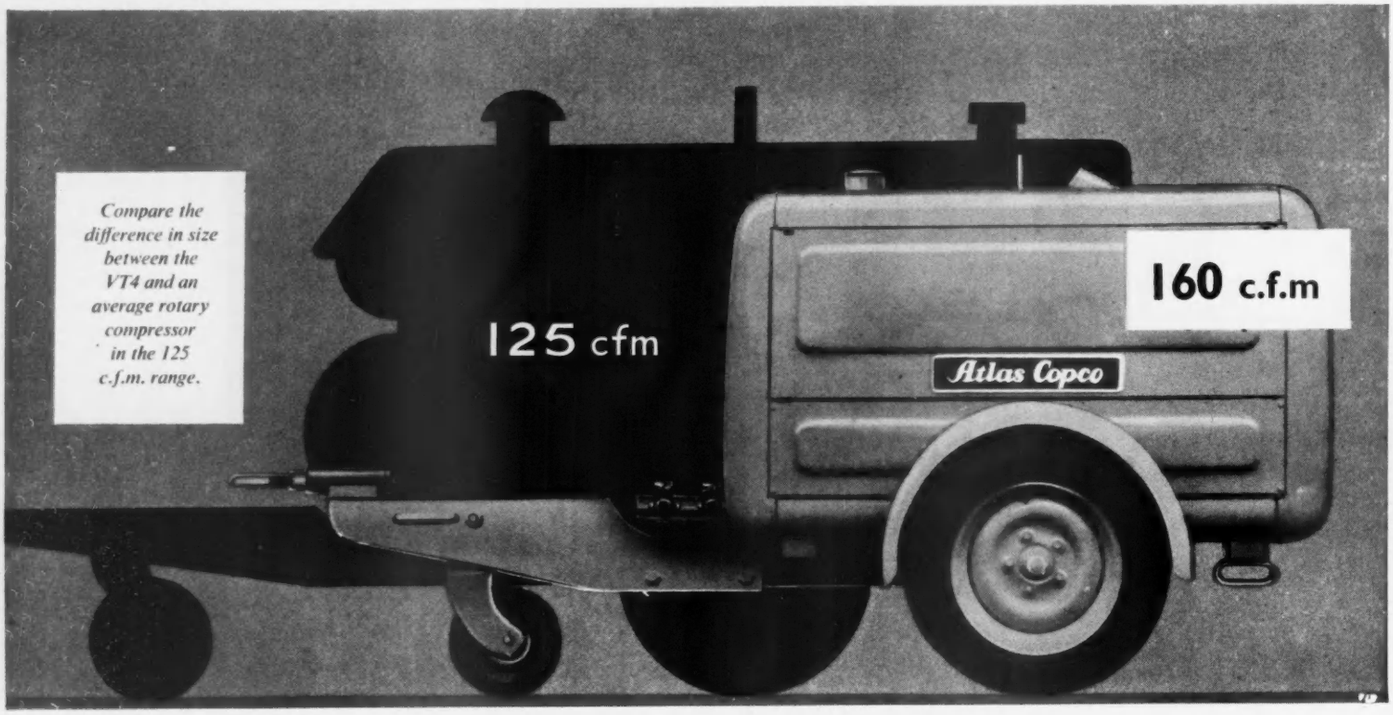
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160 c.f.m
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The VT4 is easier to load with its low weight and built-in lifting eye—easier to tow with its two wheels and torsion bar suspension.

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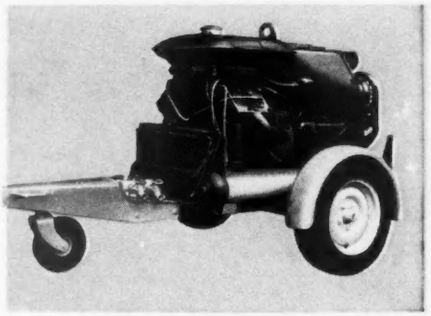

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Established 1856

No. 5359 **OCTOBER 10, 1958** VOL. 206

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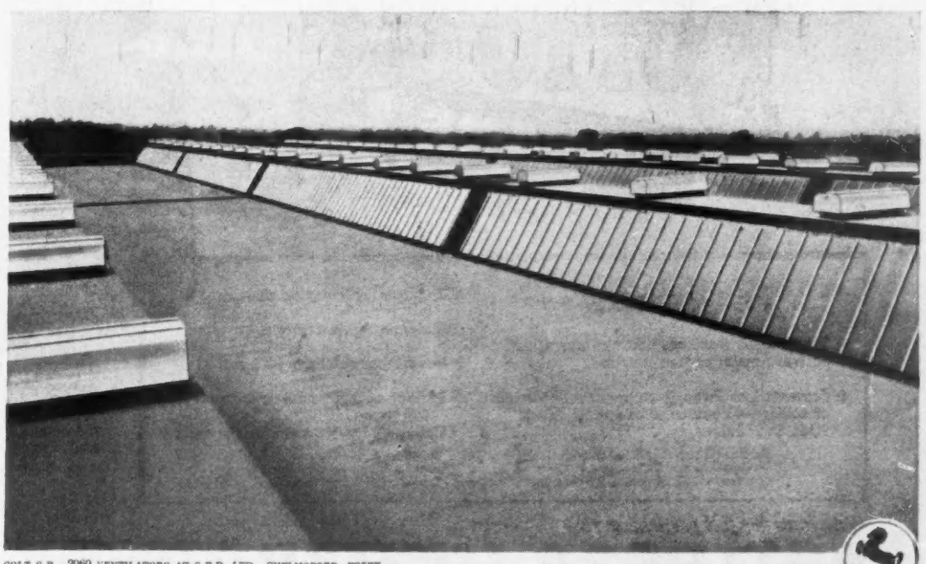

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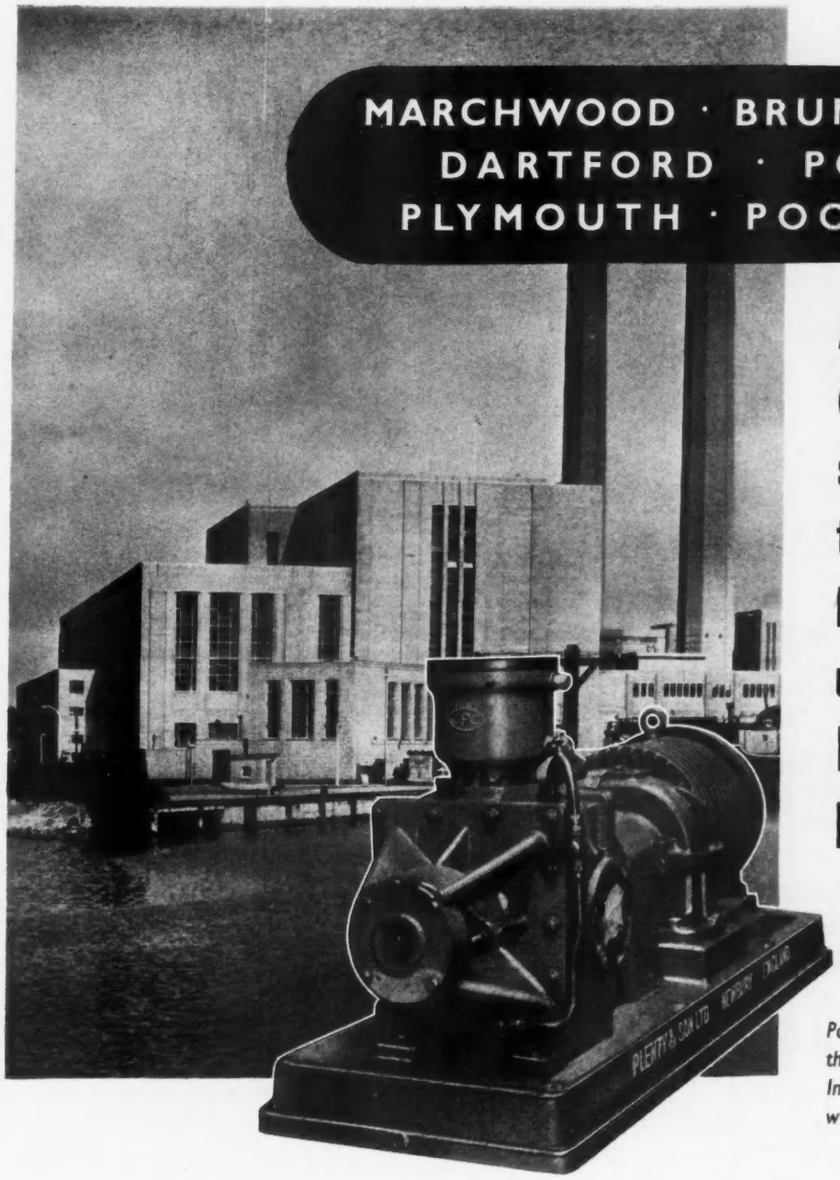

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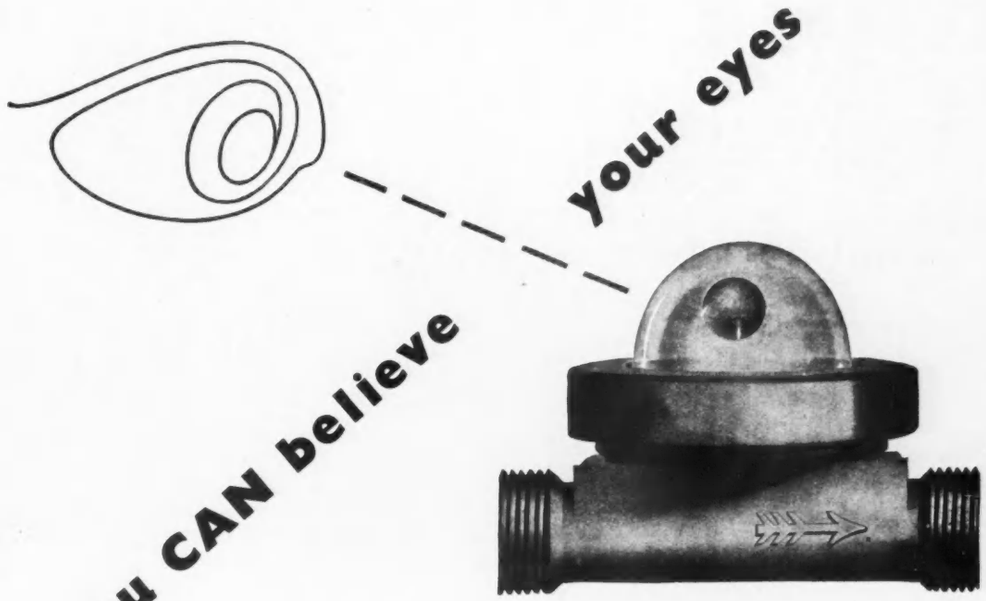

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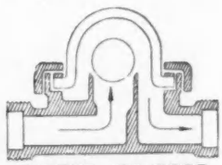

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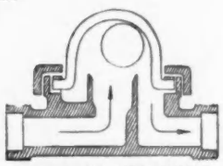

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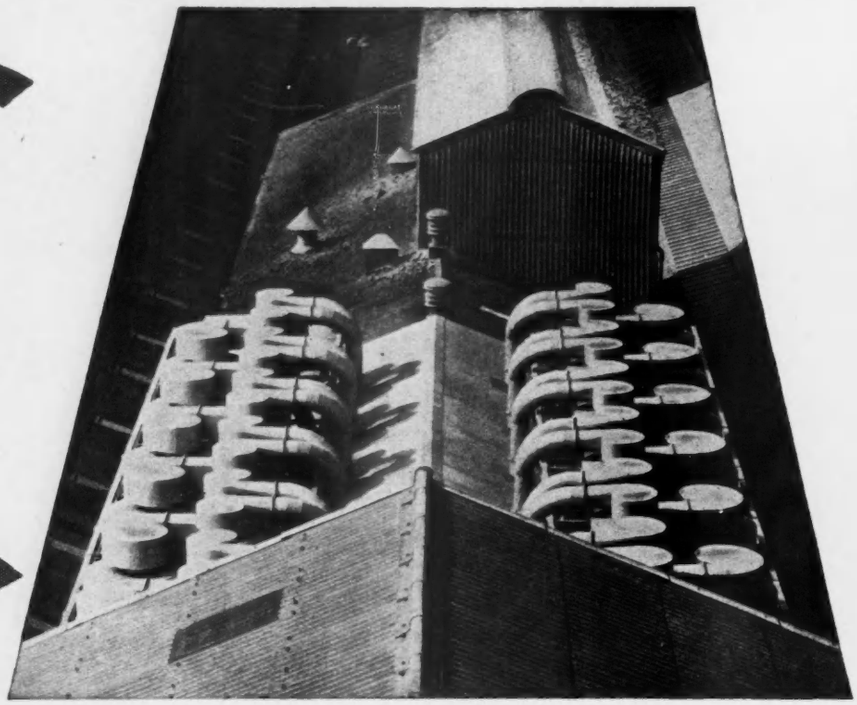

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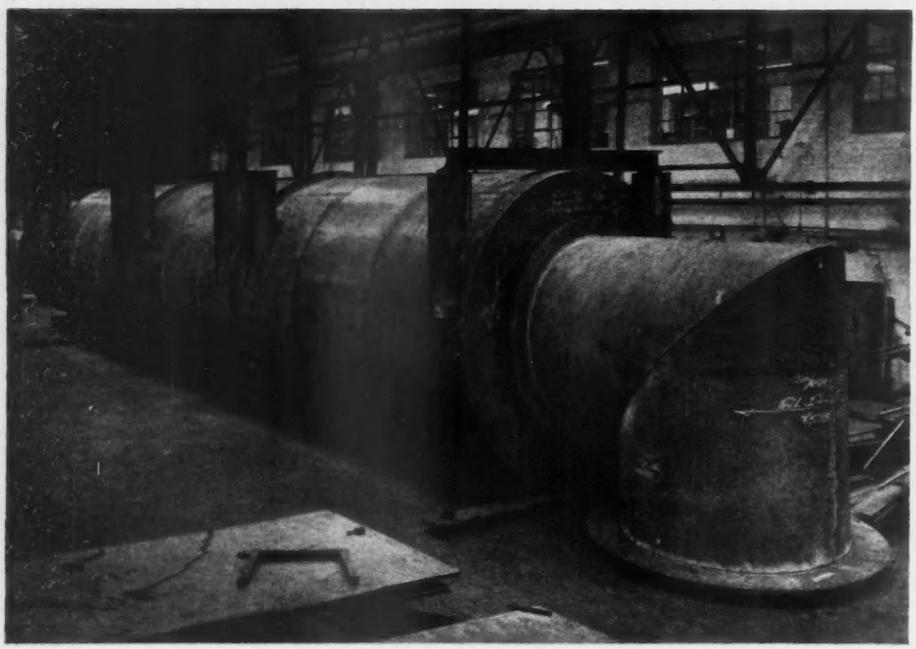

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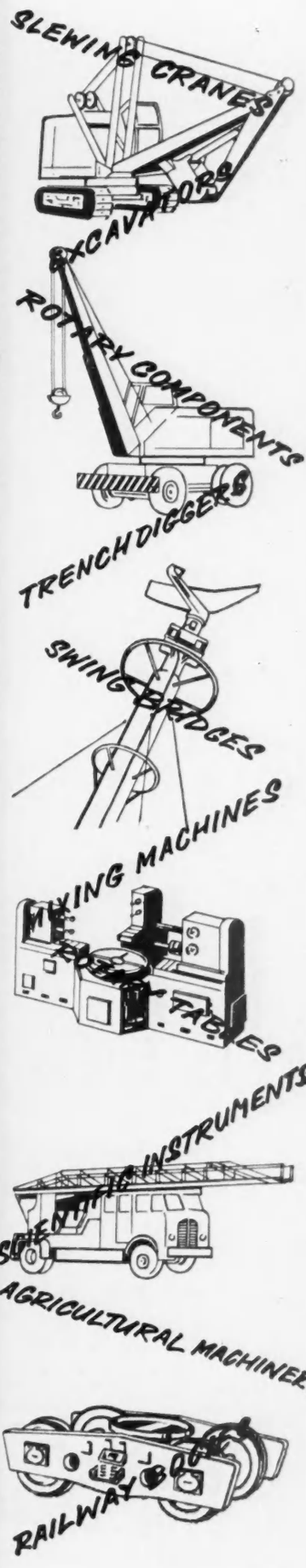

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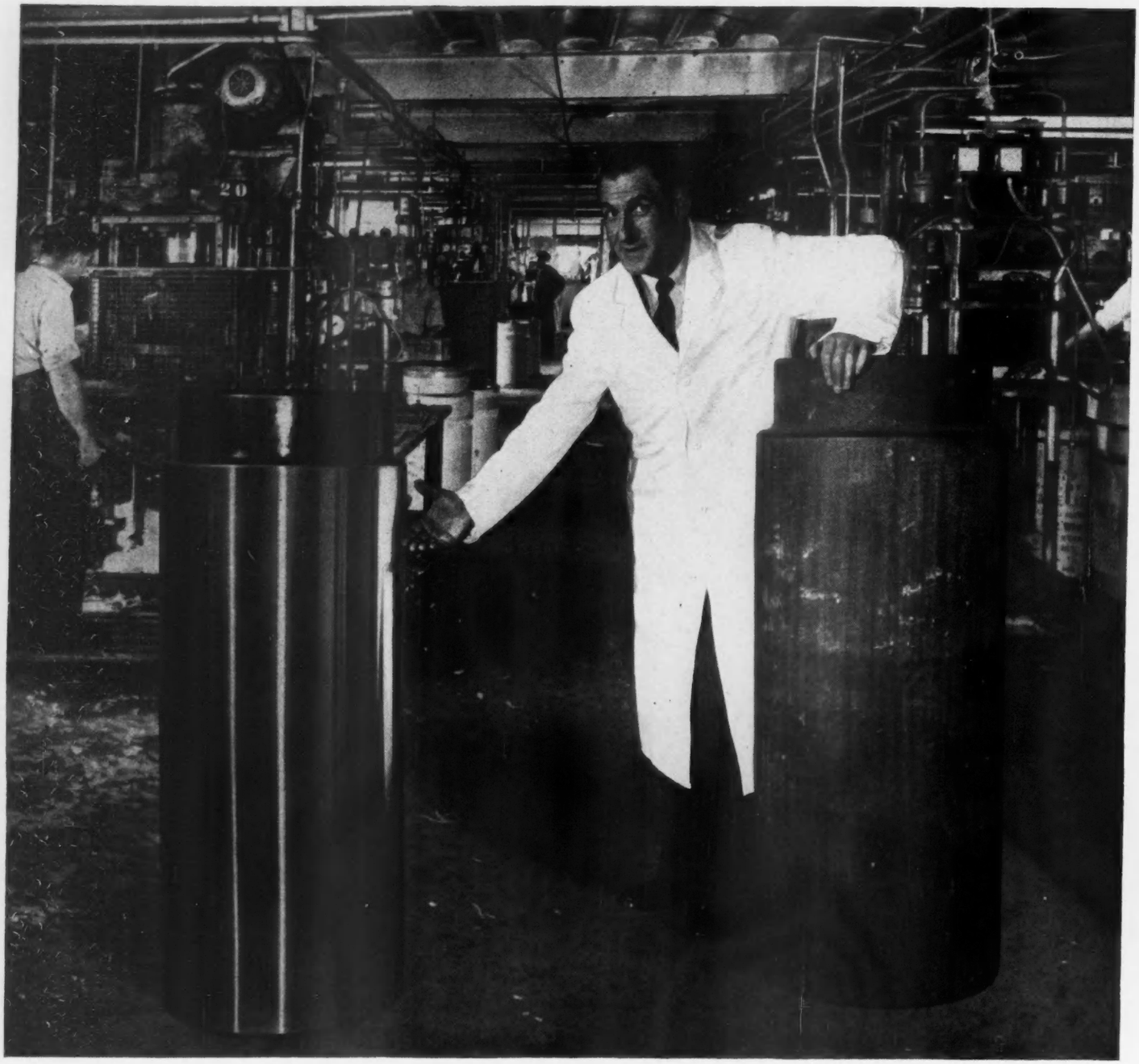

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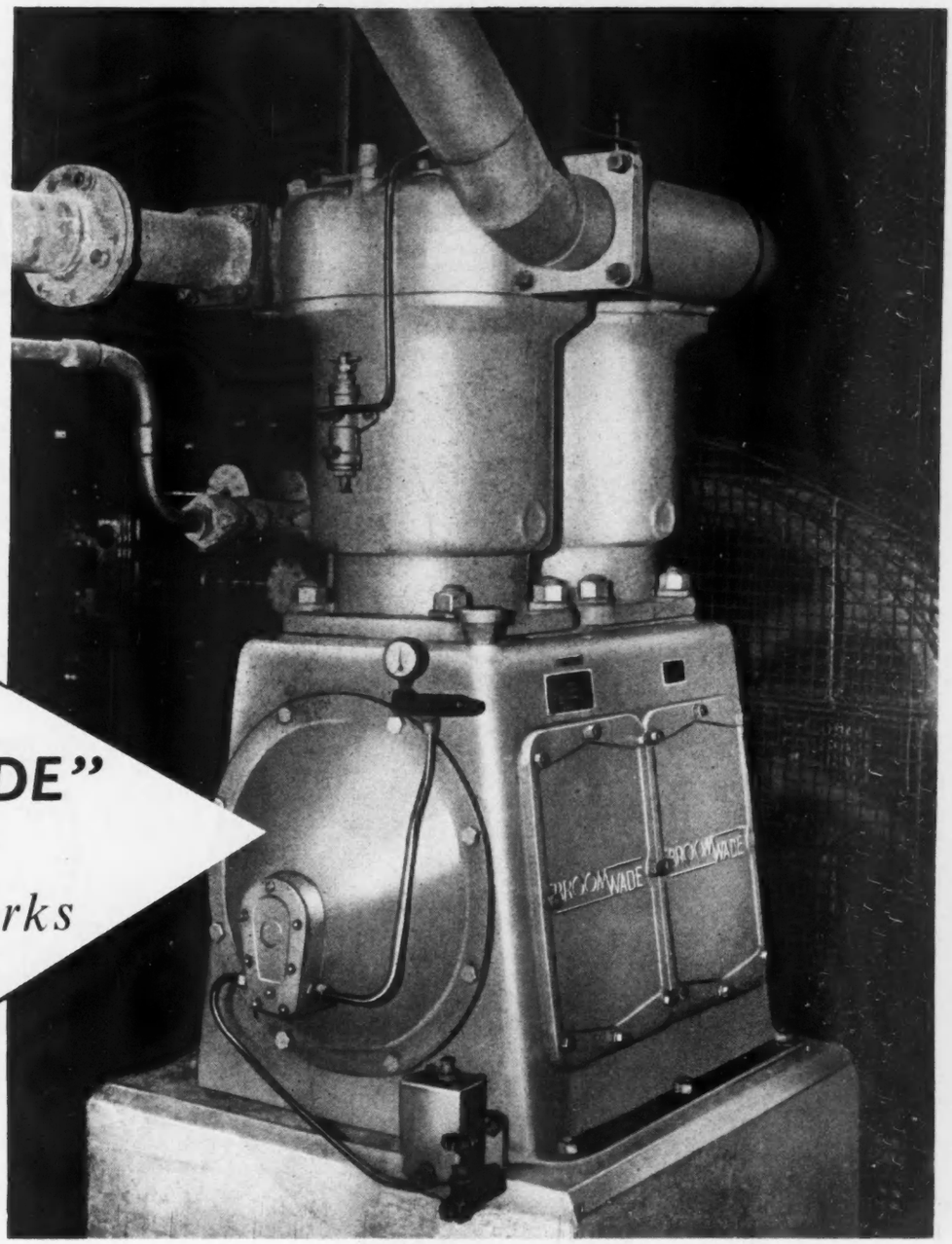

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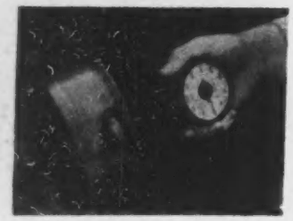

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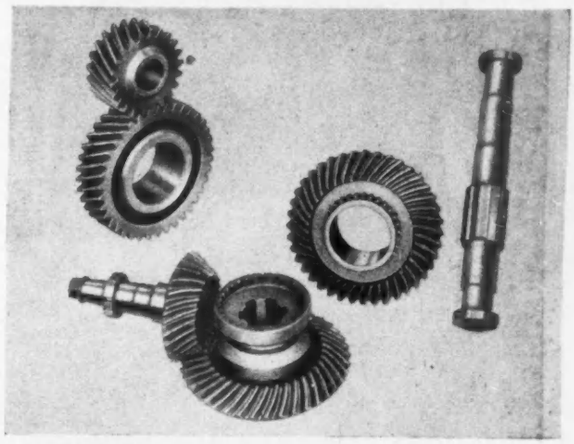

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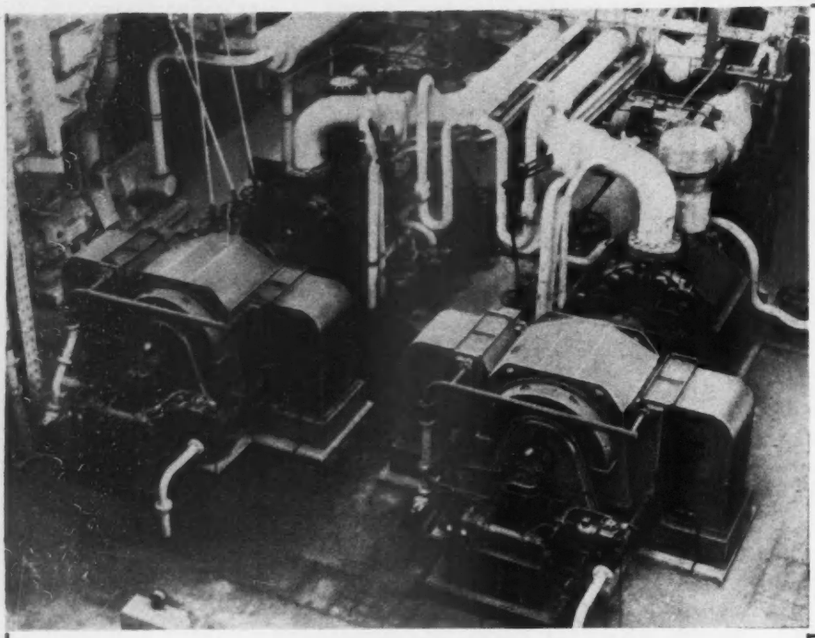

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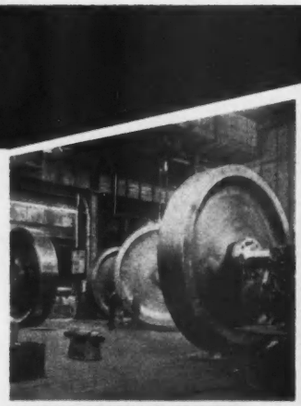

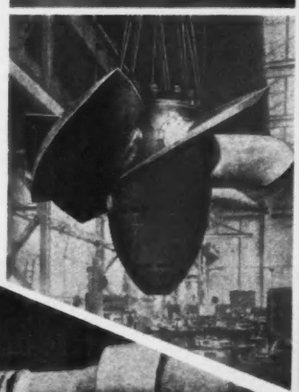

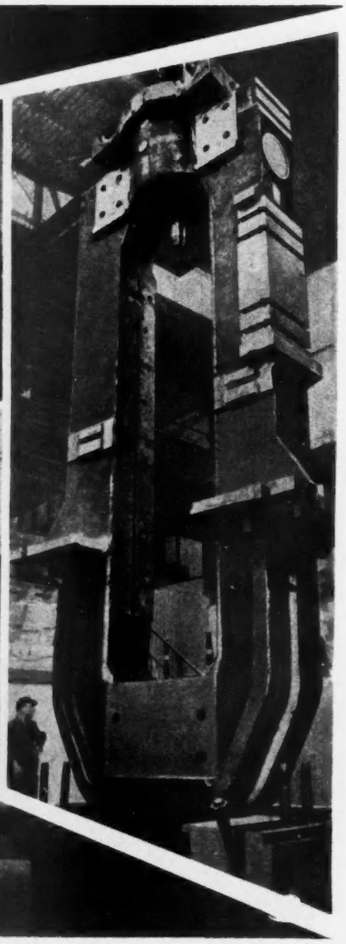

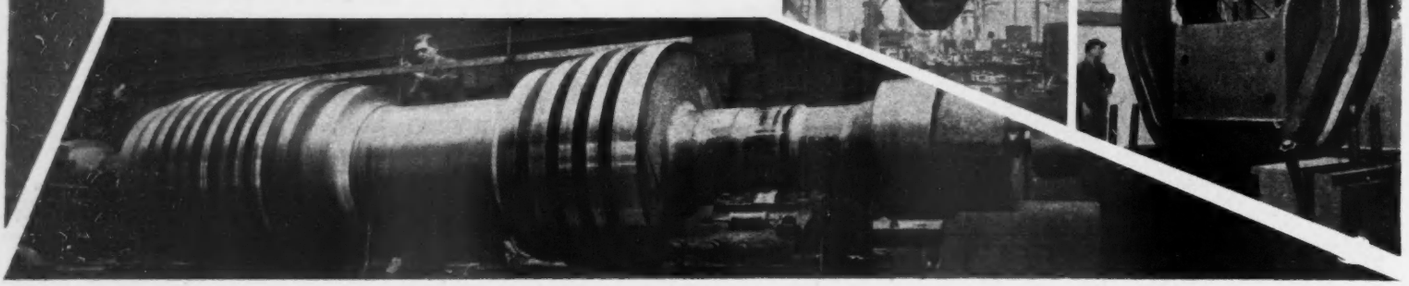

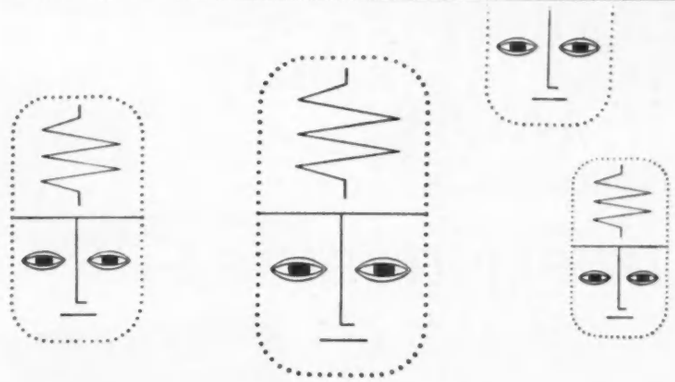

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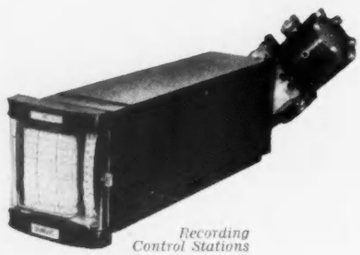

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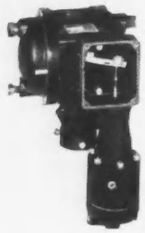

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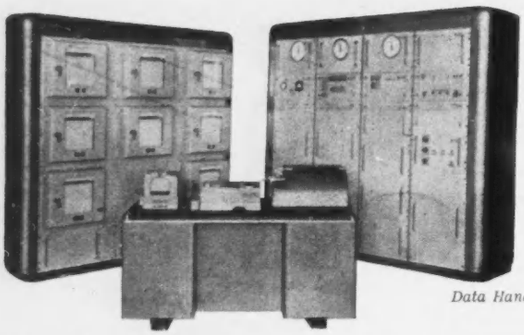

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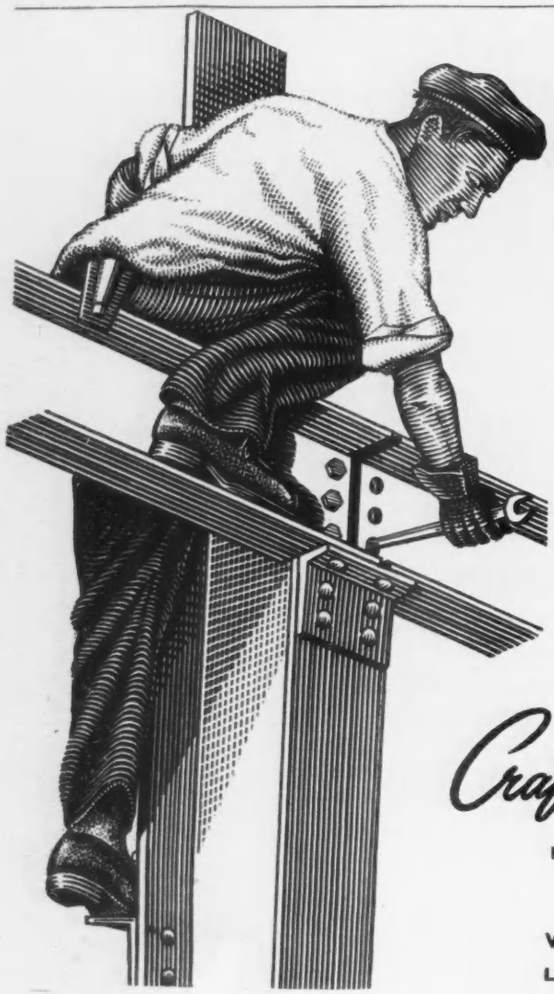

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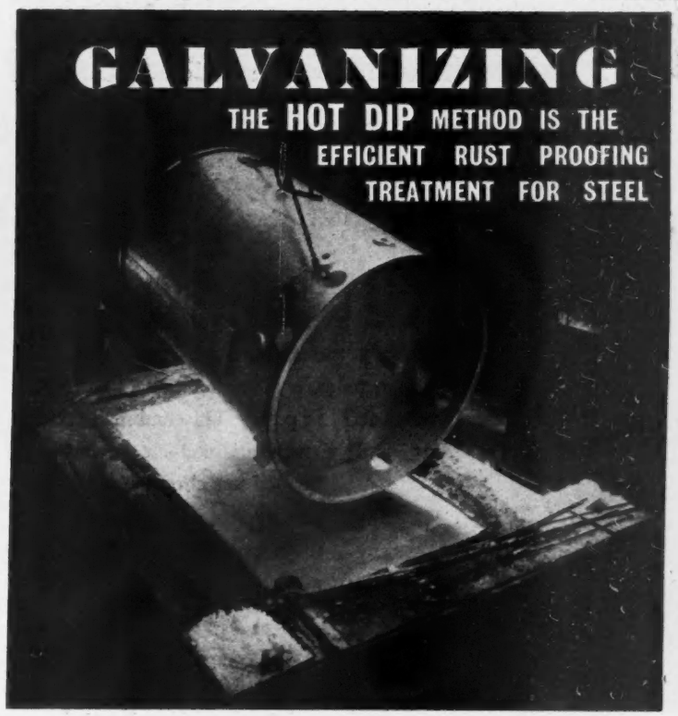

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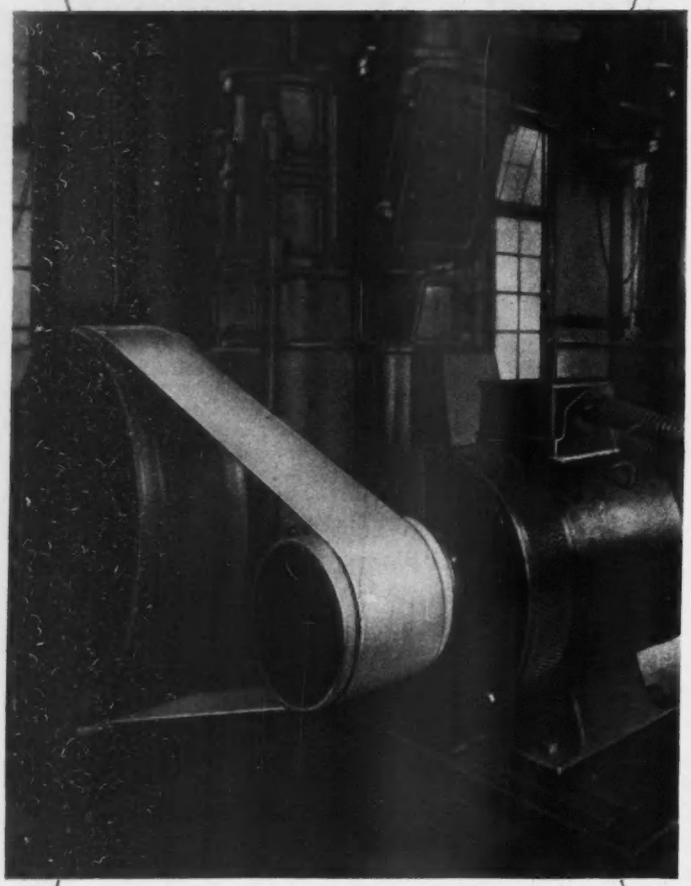

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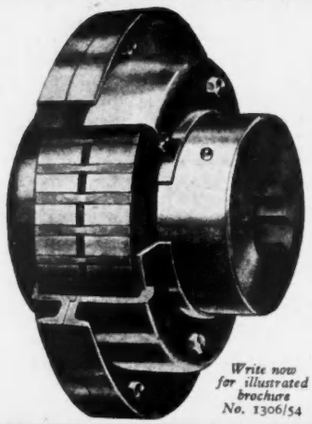

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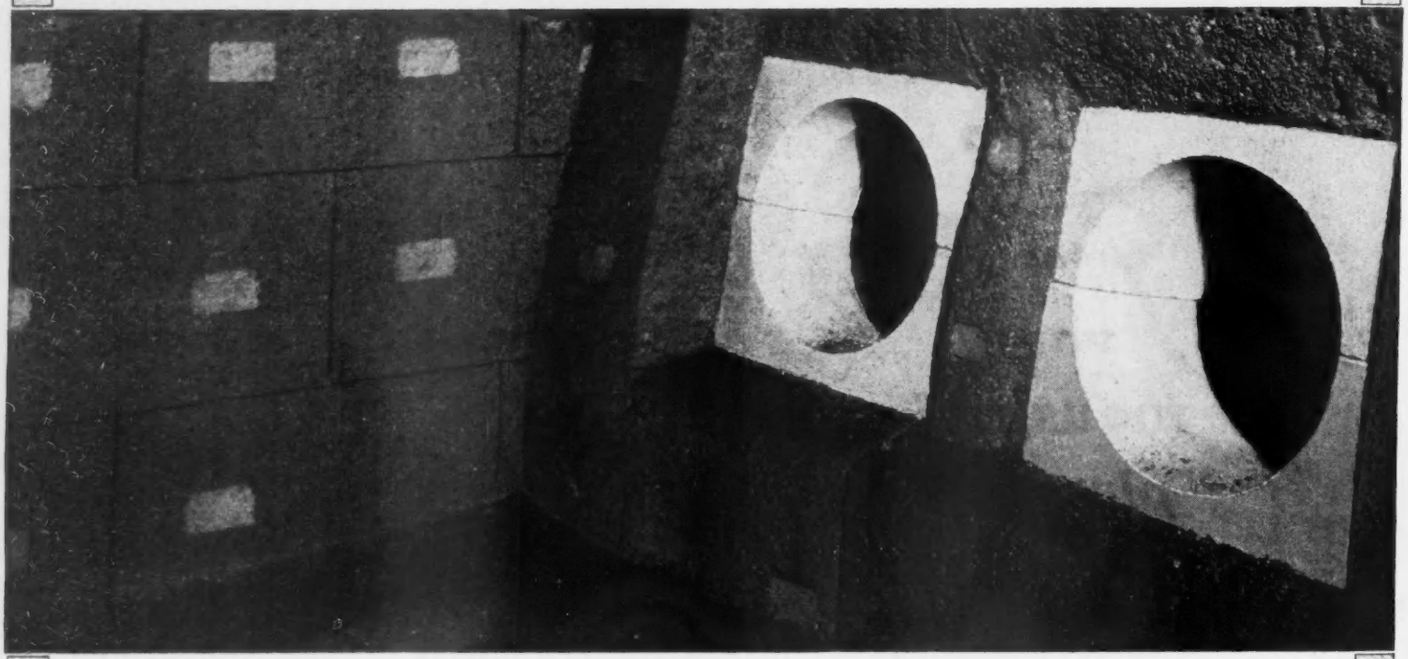

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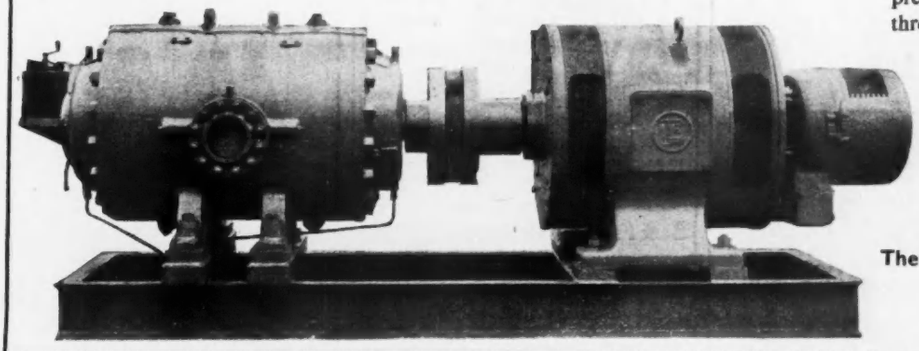

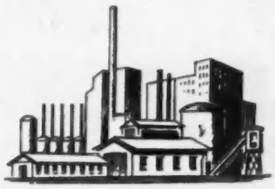

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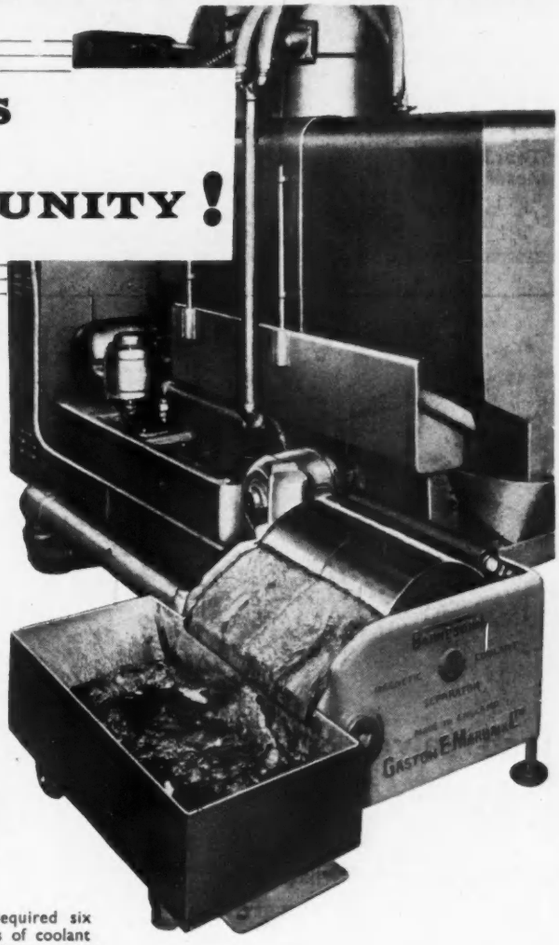

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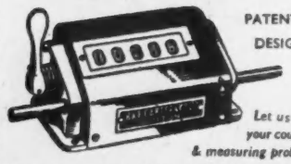

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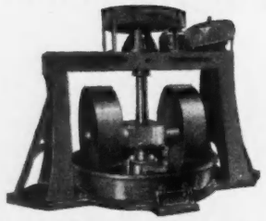

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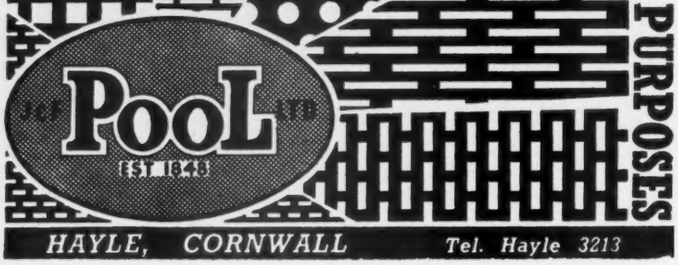

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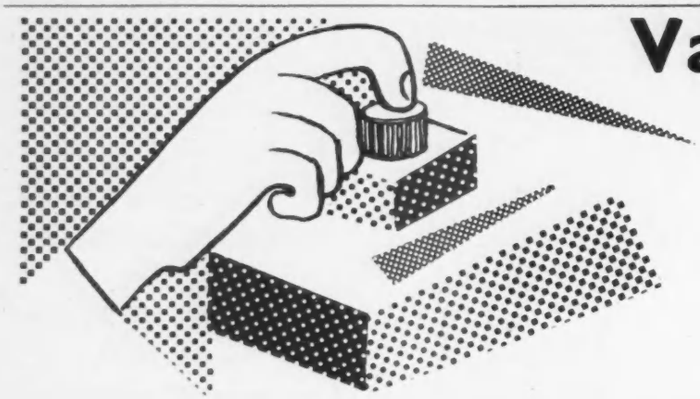

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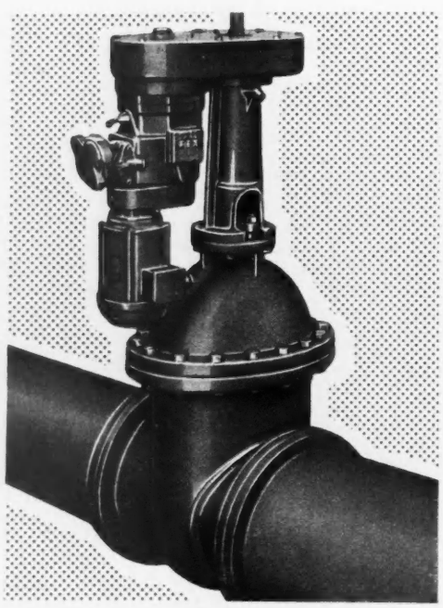

¾ h.p. servo-motor fitted to valve in water circuit by means of patented universal support; the valve remained in operation throughout erection of unit.

Motorization of a 12 inch valve at 150 p.s.i. for £150

Just a typical example of what can be achieved with one of our units selected from over twenty mass produced actuators ranging from ½ to 7 h.p.

ADAPTABILITY TO EXISTING VALVES— IMMEDIATE DELIVERY

Sales and Service Organization in the Commonwealth and throughout the world.

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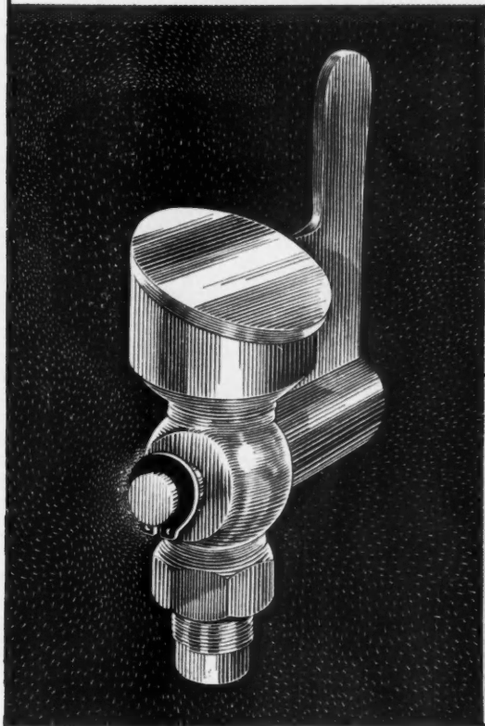
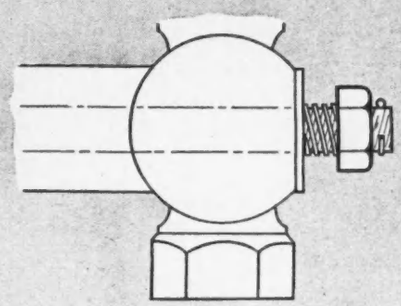
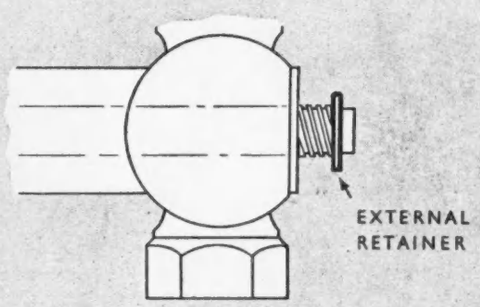
The logical advance in Retaining





OLD WAY
To provide a shoulder for the tensioning spring on this filler cup entailed an extra long, threaded shaft, a nut, a hole drilled to take a cotter pin and an altogether tedious assembly.



THE SALTER WAY
The spring is quickly positioned on a shorter, **PLAIN SHAFT** by a ***Grip Ring*** which is snapped into position for secure, frictional grip. No groove required.

save material—reduce assembly time—cut costs

When it's a question of assembling components in any engineering field, Salter Retainers are the answer. They replace nuts and bolts, screws, cotter pins, and eliminate expensive threading and machining operations. A large standard range is at your immediate disposal, and we should welcome the opportunity to assist in developing special retainers to solve your problems.

Send for the Salter Retainer catalogue
—no designer is complete without it.

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SALTER "TRUARC" Regd. Trade Mark

Circlips Fasteners Retainers Fixes

Geo. Salter & Co. Ltd., West Bromwich. *Spring Specialists since 1760*

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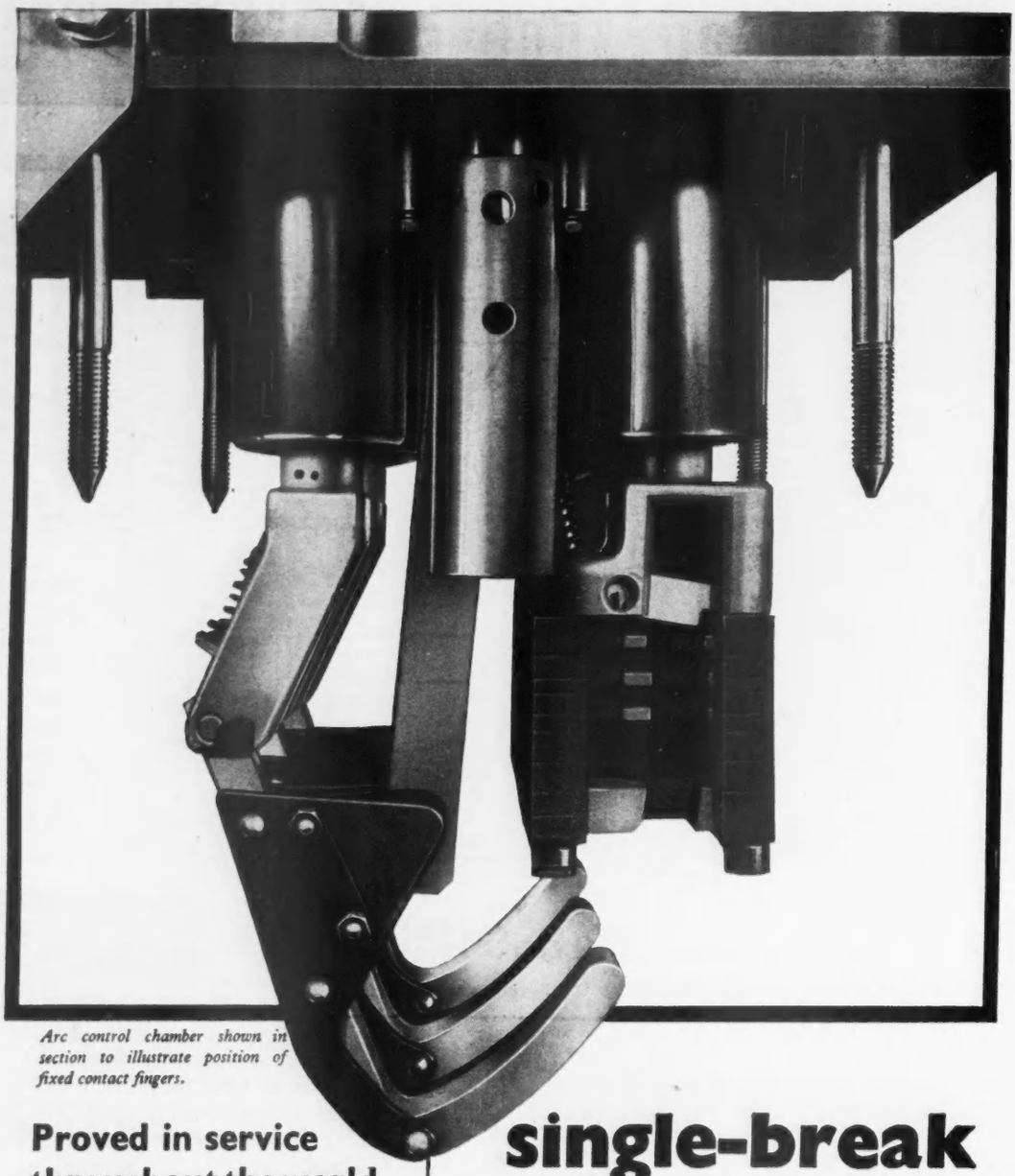

Arc control chamber shown in section to illustrate position of fixed contact fingers.

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BTH single-break oil circuit-breakers—designed for metalclad switchgear—have the inherent advantages of compactness, simplicity, and ease of maintenance. The arc-control chambers and silver-plated high-pressure line contacts ensure high performance and consistent operation.

single-break oil circuit-breakers

by B T-H

up to 15 kv. up to 2,000 amp.

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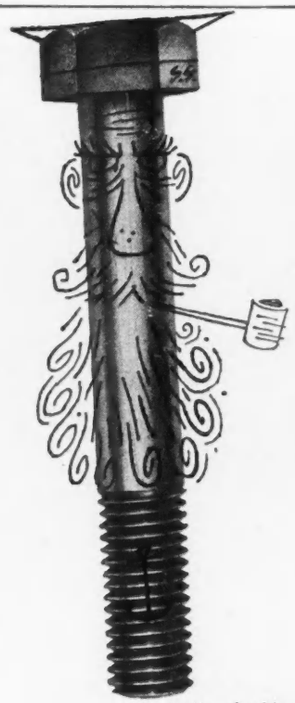

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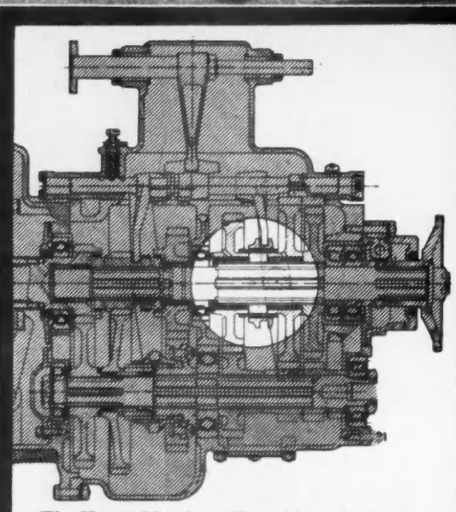
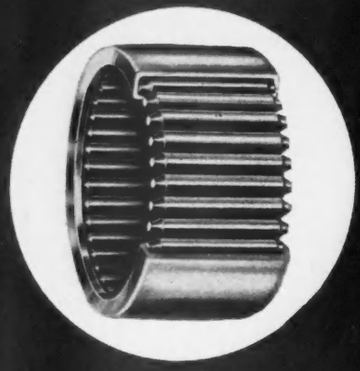
Contributing to the reliable performance and ease of operation of vehicles made by Guy Motors Limited, Torrington Needle Bearings are used in transmissions, brake cam shafts, change speed mechanisms and brake hook-up arrangements.

Smooth efficient operation and easy maintenance are assured since the bearings start and operate with the minimum of friction and retain lubricant effectively.

If your product would benefit from compact, anti-friction Needle Bearings with high capacity, long service life at low cost, write to our Bearings Division.



The Henry Meadows Type 450 C5 five-speed gearbox, in which Torrington Needle Bearings support mainshaft gears, transmits the power in the Guy 'Invincible' Chassis.



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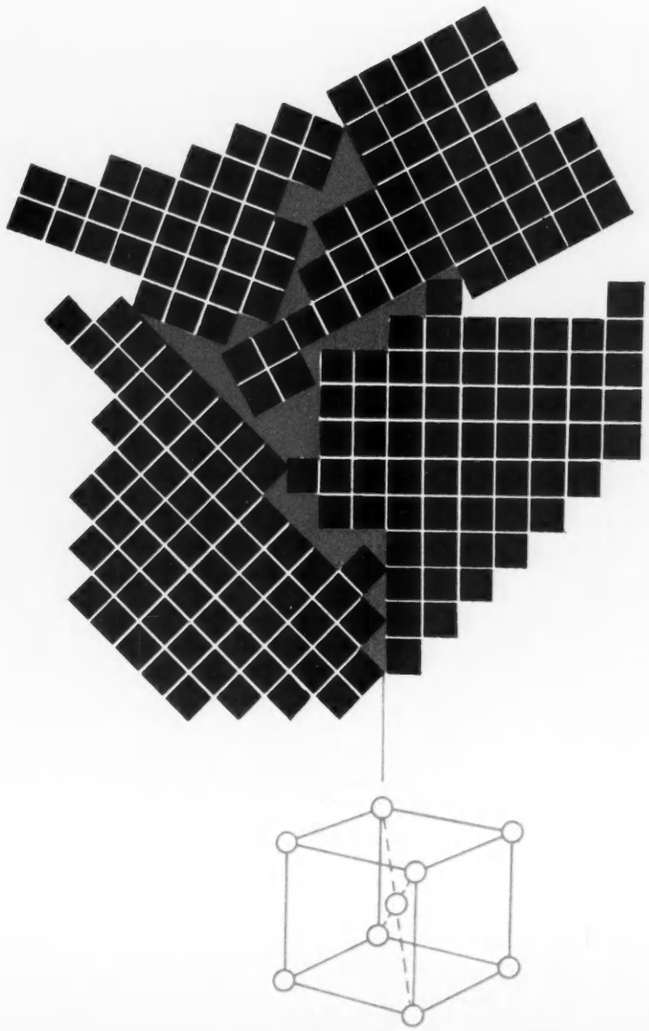
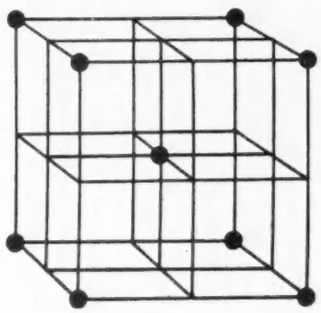
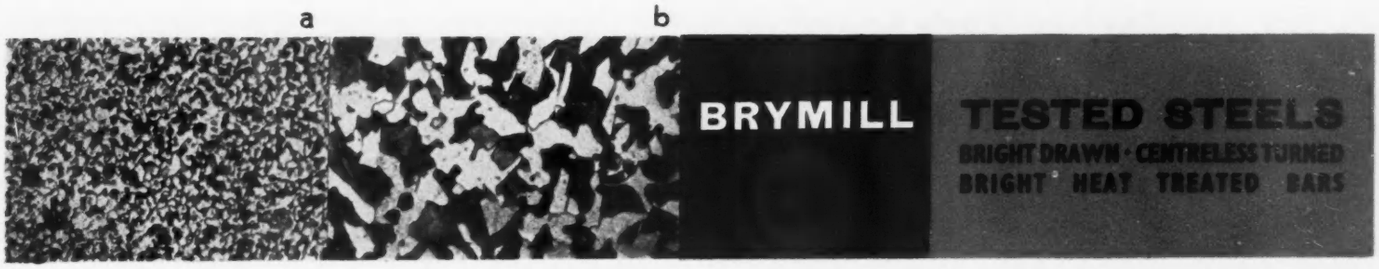
BRYMILL Laboratories will be happy to advise on the grades of steel most suited to your particular need.





a b



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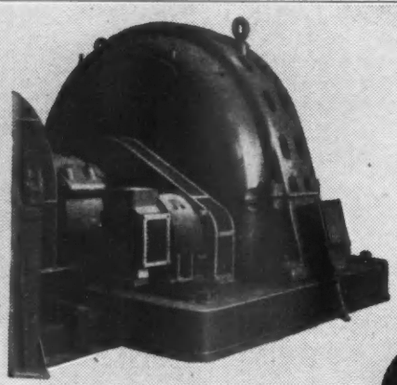
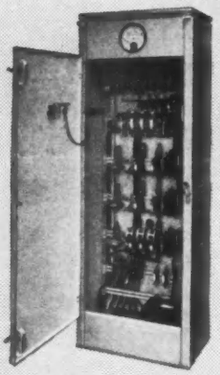


CONTACTOR TYPE SWITCH GEAR



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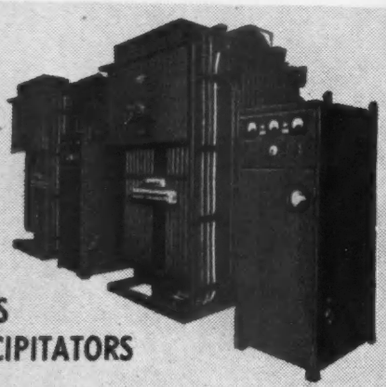
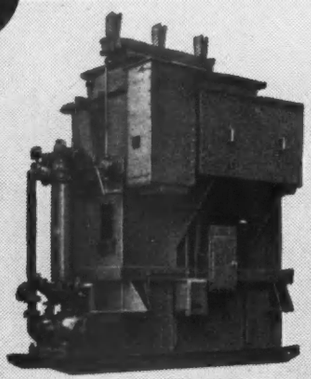


RECTIFIERS FOR PRECIPITATORS



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Bridge building with SAFWAY

THESE ARE THE FACTS

1 The whole of the scaffolding supporting the shuttering for this bridge erected in 1,100 man hours.

2 Labour force of only five men on scaffolding (3 of which were unskilled).

3 Only Safway equipment used throughout.

4 Size of each arch 75 ft. x 25 ft. 6 ins. x 28 ft. 6 in. wide. Total load per arch 215 tons.

5 Minute adjustment of scaffolding to follow arch curve achieved with Adjustable screws in base and head.

6 Joiners work reduced to a minimum.

Contractors : H. M. Murray & Co. Ltd., Glasgow and Inverness.

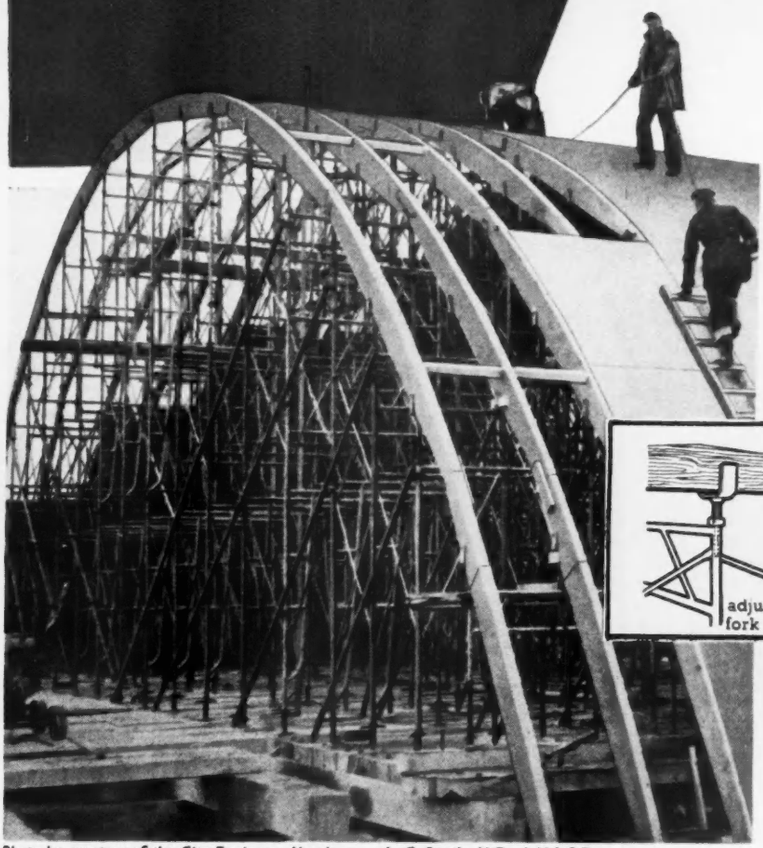

Photo by courtesy of the City Engineer, Aberdeen — A. G. Booth, M.E., A.M.I.C.E.

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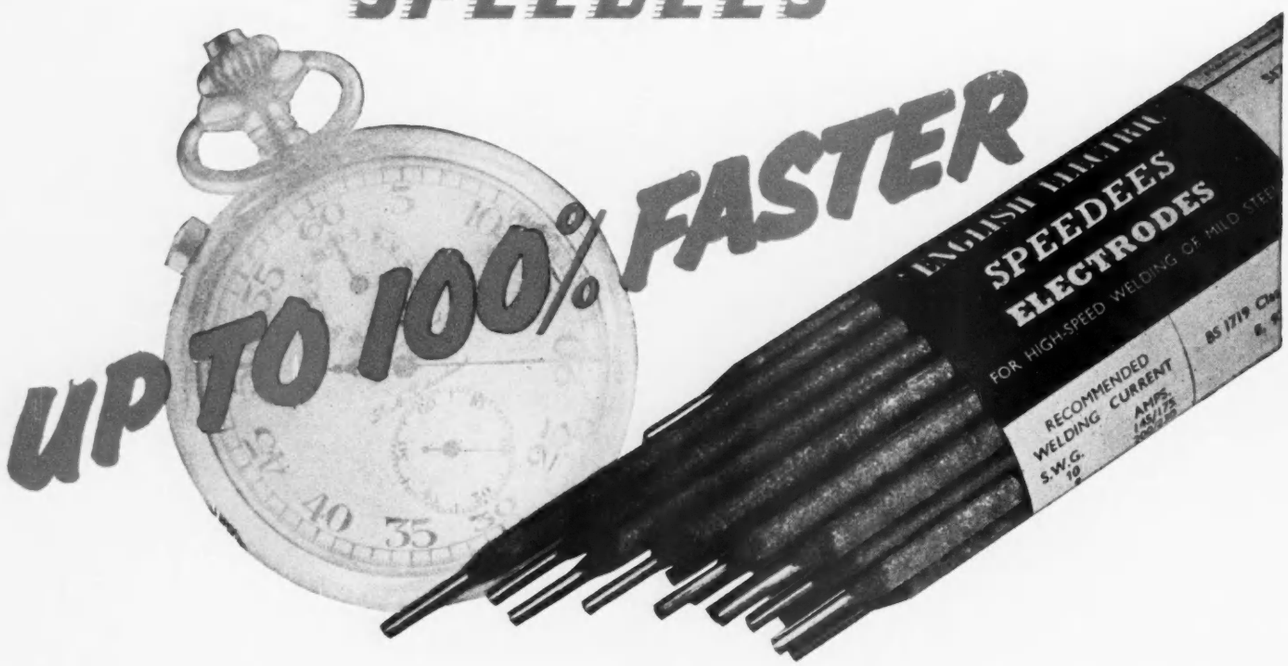
Cogent

The electrodes for

FASTER WELDING

are

SPEEDEES



SPEEDEES welding electrodes have been developed by 'ENGLISH ELECTRIC' specifically for easier, faster and more economical welding of mild steel. They produce well-shaped fillets with an extremely smooth finish. An iron powder is incorporated in the electrode coating, and in practice SPEEDEES have proved to increase production rates by anything up to 100% as compared with conventional electrodes of the same gauge.

Send for publication WA/132 and literature covering the range of standard 'ENGLISH ELECTRIC' welding electrodes.

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THE ENGLISH ELECTRIC COMPANY LIMITED, MARCONI HOUSE, STRAND, LONDON, W.C.2

Welding Electrode Division, Clayton-le-Moors, Accrington, Lancs.

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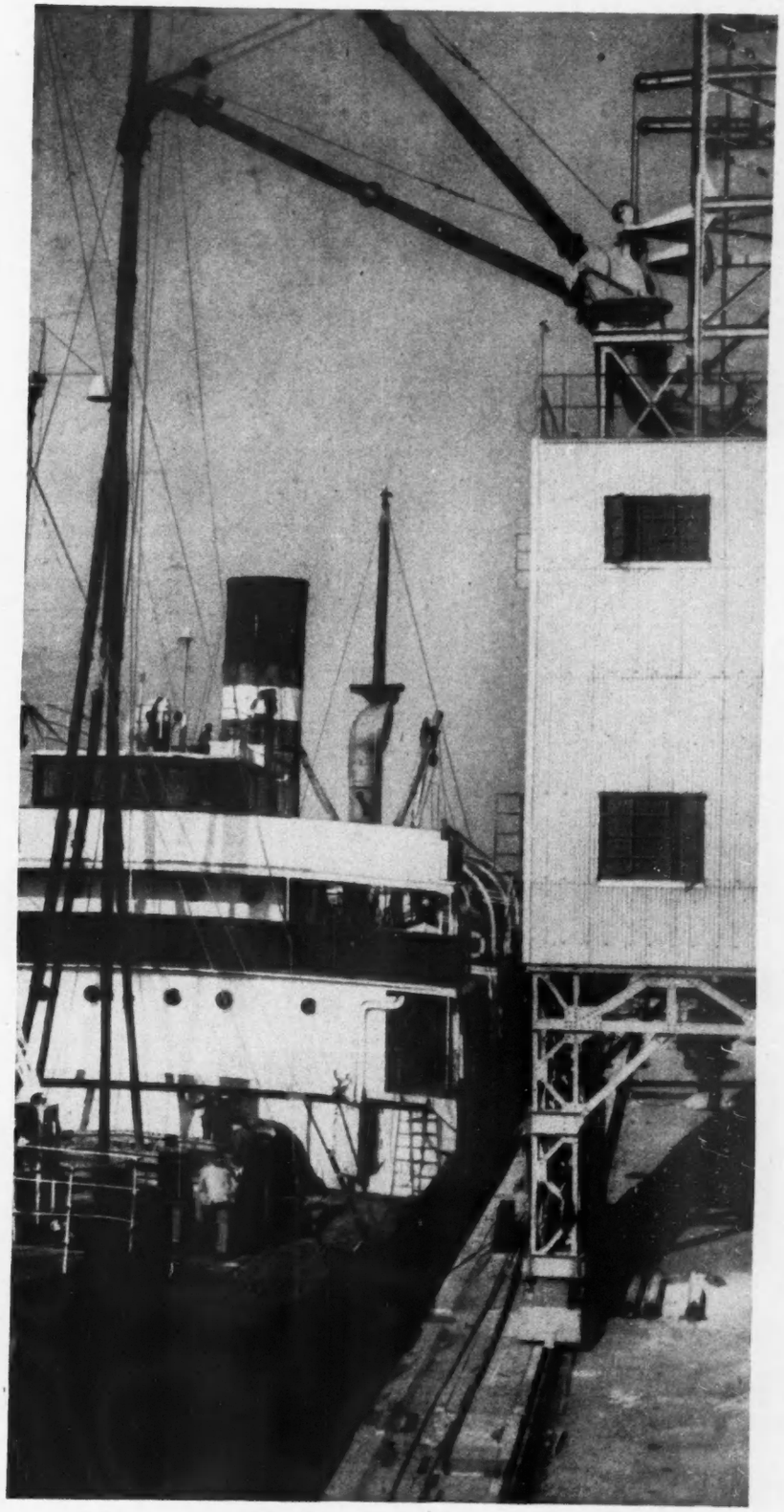

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BIG..

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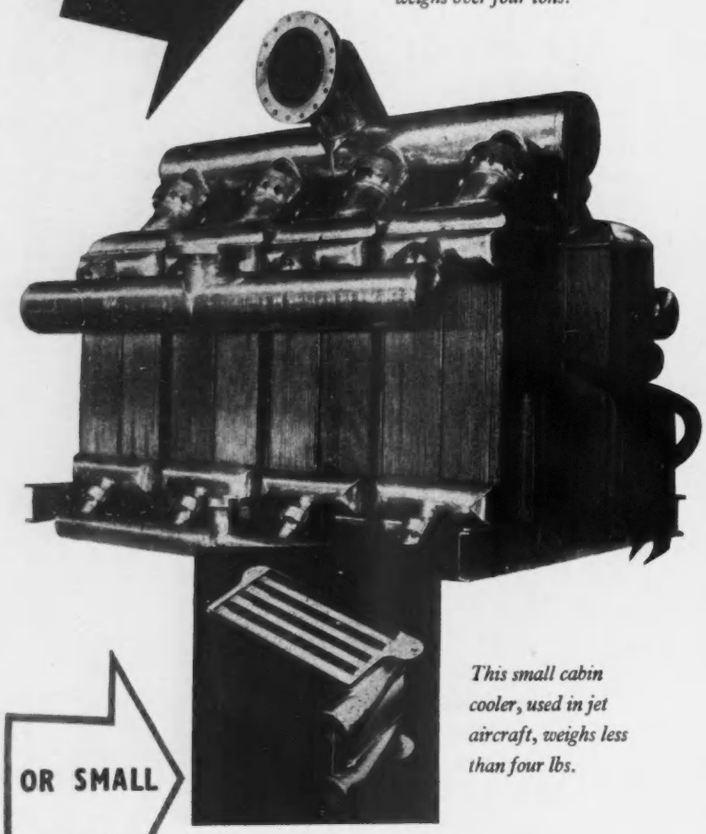

OR SMALL

This small cabin cooler, used in jet aircraft, weighs less than four lbs.

it's all the same to Marston's

Size and weight are no problems for Marston's when it comes to heat exchanger equipment. Radiators, oil coolers or air heat exchangers — the Marston range is unrivalled. So is their experience. Used in the finest cars, the most advanced aircraft, and the vital branches of industry, Marston products combine high efficiency with outstanding reliability.

For assistance on any problem connected with heat exchangers, get in touch with

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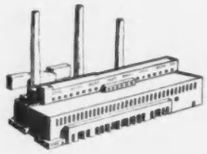
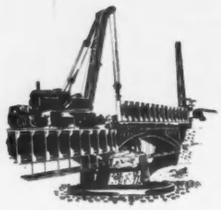
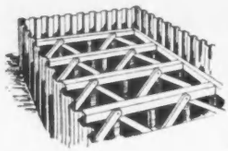


POWER STATIONS Cleveland have played their part in meeting Britain's need for more electrical energy. The huge steel frames have been fabricated at top speed with highly developed welding techniques. Members are produced up to 95 ft. long and 42 tons in weight, with a tolerance in length, twist or bow not exceeding ¼ inch.

CLEVELAND



RAILWAYS Movement of merchandise and people becomes yearly a greater task. Cleveland are helping not only with the construction of new bridges, but the re-construction and repair of old bridges.



DEEP FOUNDATIONS Necessity and not the ease of engineering dictates where many structures must be sited. So deep foundations are needed. Cleveland have wide experience all over the world and can be relied on to appreciate difficulties and find sound solutions.

As new needs occur, so new problems arise. Cleveland welcomes the chance of assisting in their solution. Excellent facilities are available for design, detailing, fabrication and construction.

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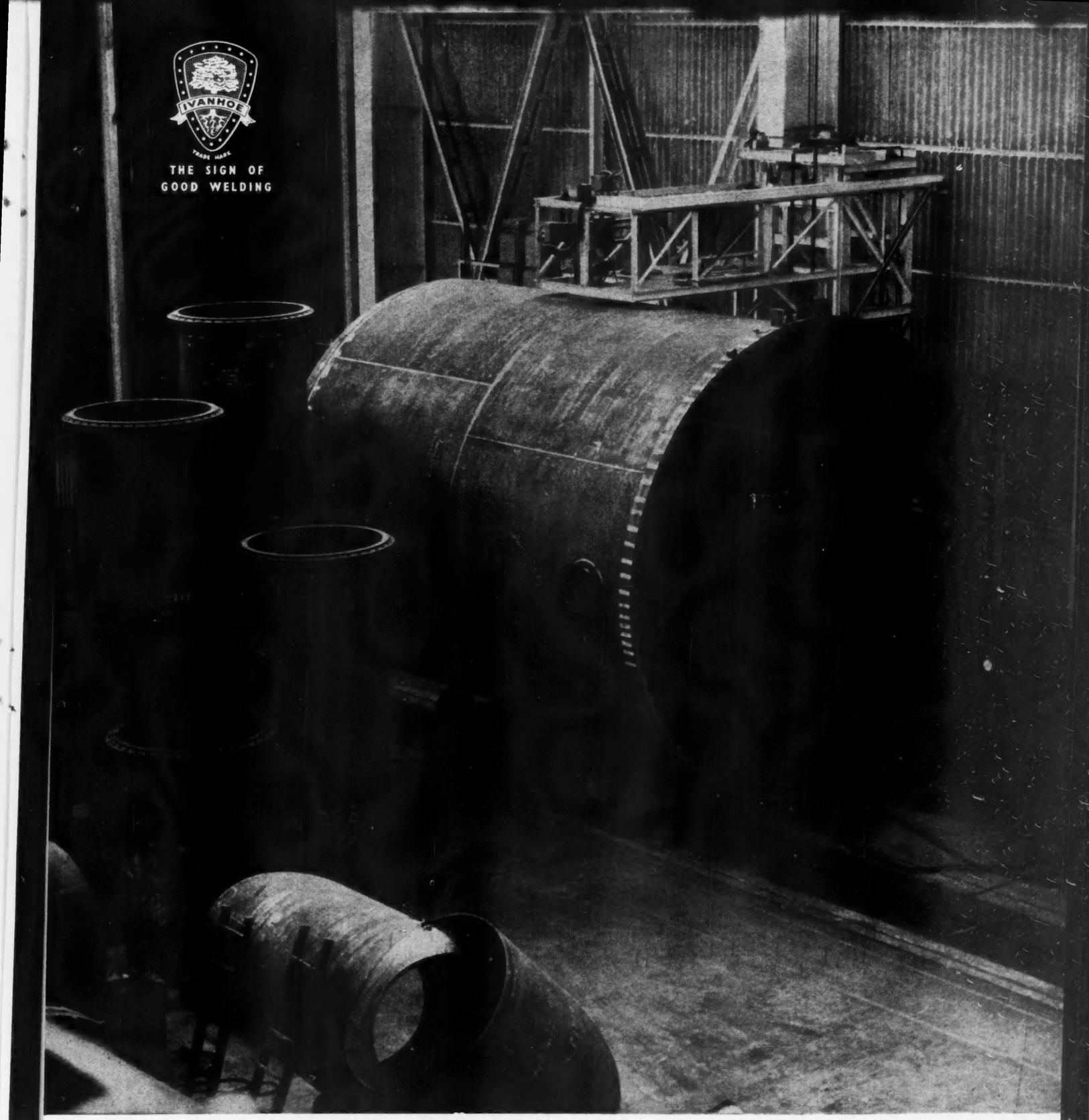

Submerged arc welding of 16′ diameter vessel in the North Greaves Shop.

Jenkins fabricate fractionating columns, heavy pressure vessels and similar large plant up to 60 tons. Boring capacity to the following limits is also available :

Boring spindle		7″
Longitudinal traverse	5′	4″
Transverse traverse	11′	0″
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Maximum facing diameter	8′	0″

Welded fabrications and fusion-welded pressure vessels to the requirements of Lloyds Class 1, A.S.M.E., A.O.T.C. codes and similar specifications.

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HOW MUCH FOR THIS?

. . . . not more than a shilling, maybe, but a single damaged bolt or other screw threaded part can cost pounds if a replacement is not readily available when it is wanted and essential machinery is standing idle. But there is no need to take chances because there is a certain safeguard and it costs only 27/6d.—the Edwards' Patent Bolt Saver and Thread Restorer!

Unquestionably, the Bolt Saver is the most efficient tool for restoring damaged threads and it is the easiest to use, too: Simply insert damaged part, close tool by means of clamp, withdraw part by unscrewing and—presto!—the damaged thread is as good as new, re-formed (*not* cut) and with full grip restored! Also invaluable as a thread gripper for holding threaded parts in the vice.

No inserts or loose parts and the one tool takes all sizes from ¼-in. to ¾-in. dia. (BSP ¼-in. to ½-in.). There are models for the following threads: BSW, BSF, ANF/SAE, UNF, Metric, Motor-cycle and BSP, all at **27/6**

Guarantee

We invite you to make this test: Knock-up good threads with a hammer and recondition with the Bolt Saver—your money back if the corresponding nut cannot easily be screwed on!

Do not take chances—equip with Bolt Savers NOW, before the next breakdown! Immediate delivery through your usual supplier or direct from

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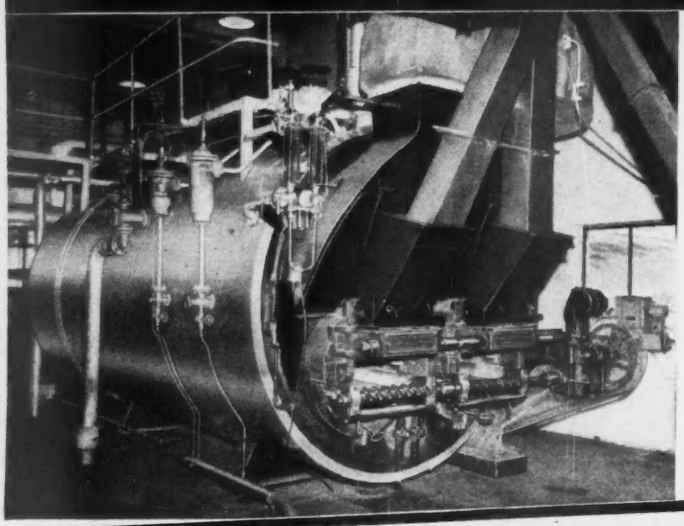


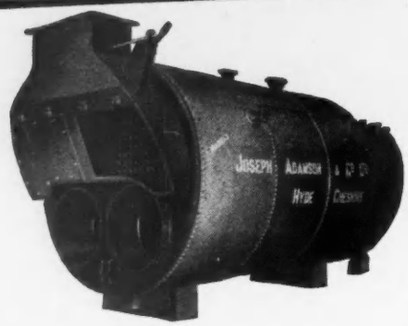
JAC

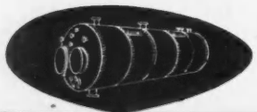
Dryback Boilers

One of two JOSEPH ADAMSON boilers selected for a new factory in Scotland.

With automatic stokers and coal handling plant they are as easy to fire as an oil-fired installation and are independent of imported fuel.

Compared with the traditional Lancashire boiler they occupy half the floor space and with clean soft water will maintain their initial high efficiency indefinitely.





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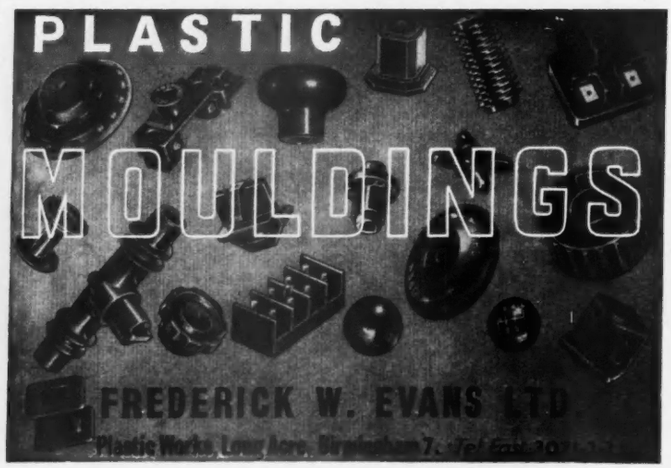

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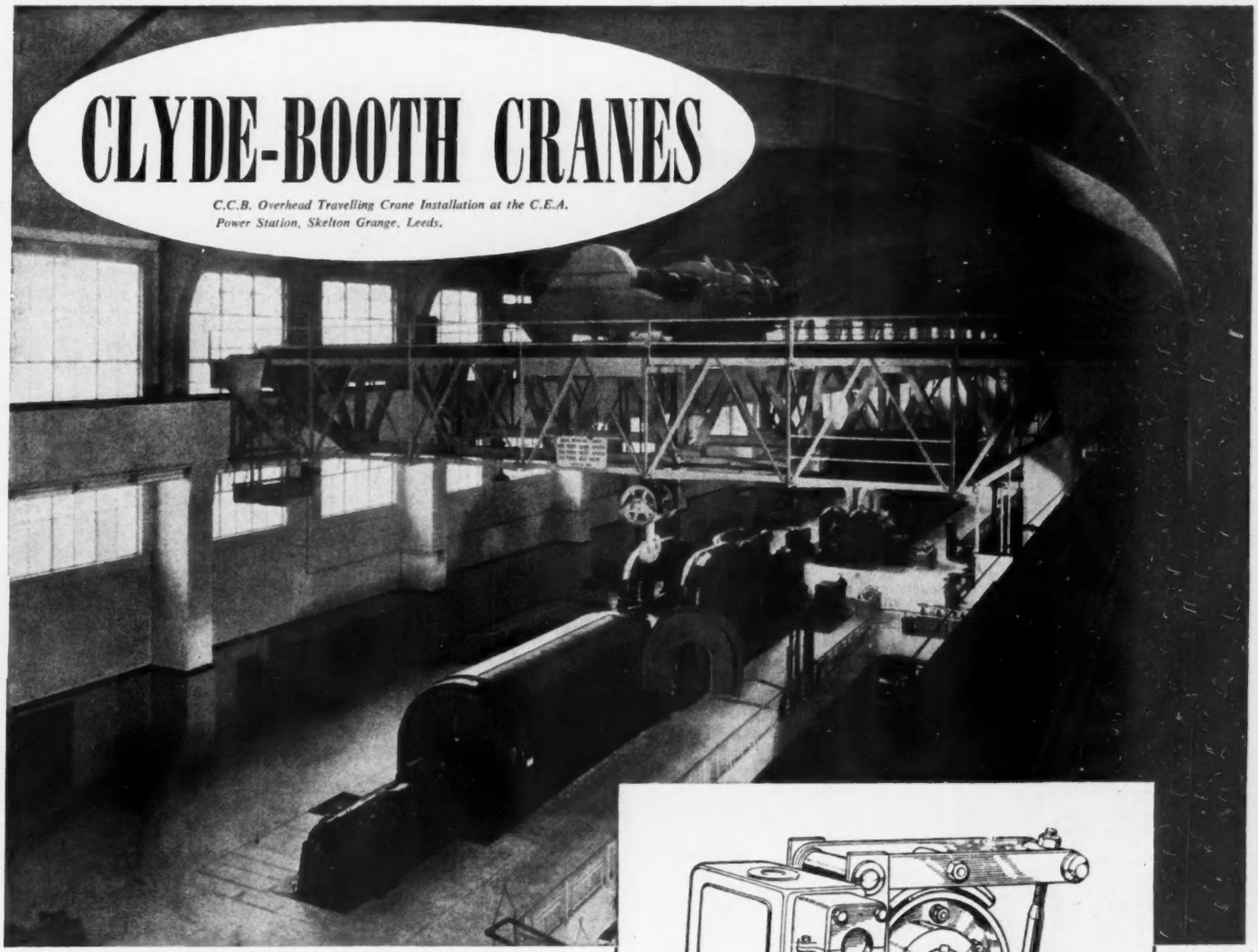
CLYDE-BOOTH CRANES

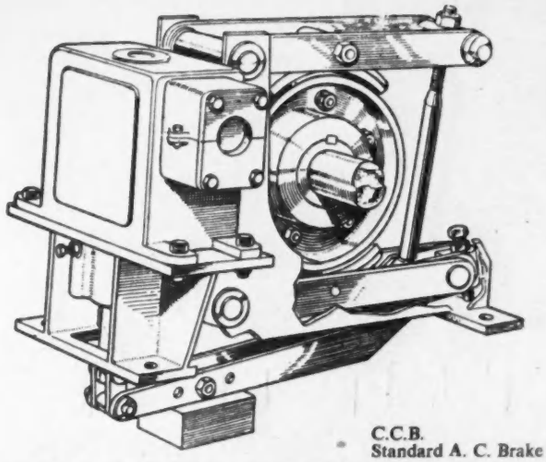
C.C.B. Overhead Travelling Crane Installation at the C.E.A. Power Station, Skelton Grange, Leeds.



Salient Features of
Clyde-Booth Design . . . .

ELECTRIC BRAKES....

The C.C.B. Solenoid brake is a compact all steel design, built to give long working life with a minimum amount of adjustment. Detail refinements include:



C.C.B.
Standard A. C. Brake

- **Hardened and ground pins working in phosphor bronze bushed links.**
- **Die pressed friction linings ground to form after fitting.**
- **Quick and easy adjustment to compensate for lining wear.**
- **Wide brake drum and shoes provide large friction area.**

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Telephone: Pudsey 3168 (6 lines). Telegrams: "Cranes," Rodley.

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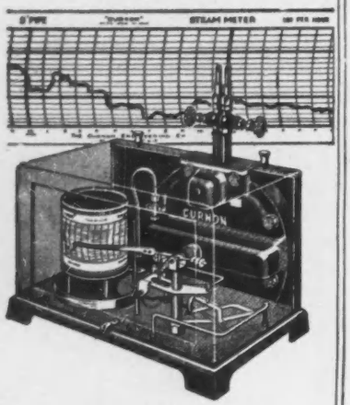
STEAM METER



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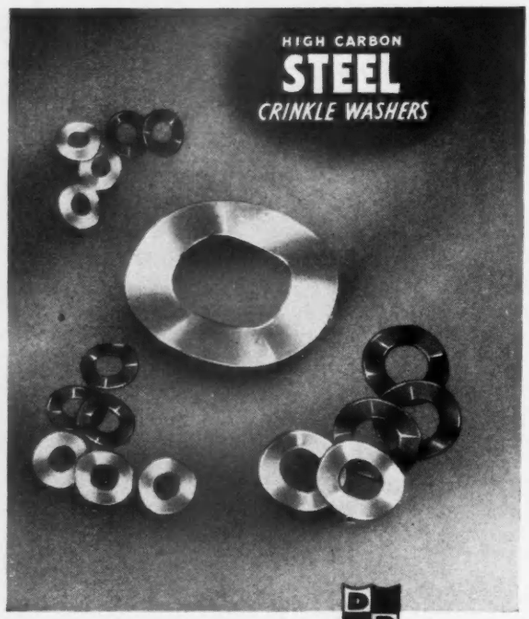

High Carbon Steel Crinkle Washers 0·75/0·85". Heat Treated and finished Blued or Plated. Its design prevents damage to polished or Plated surfaces and so eliminates a basis for corrosion. Its counter-part, made from Beryllium Copper, is extensively used in the Electrical and Electronic Industries.

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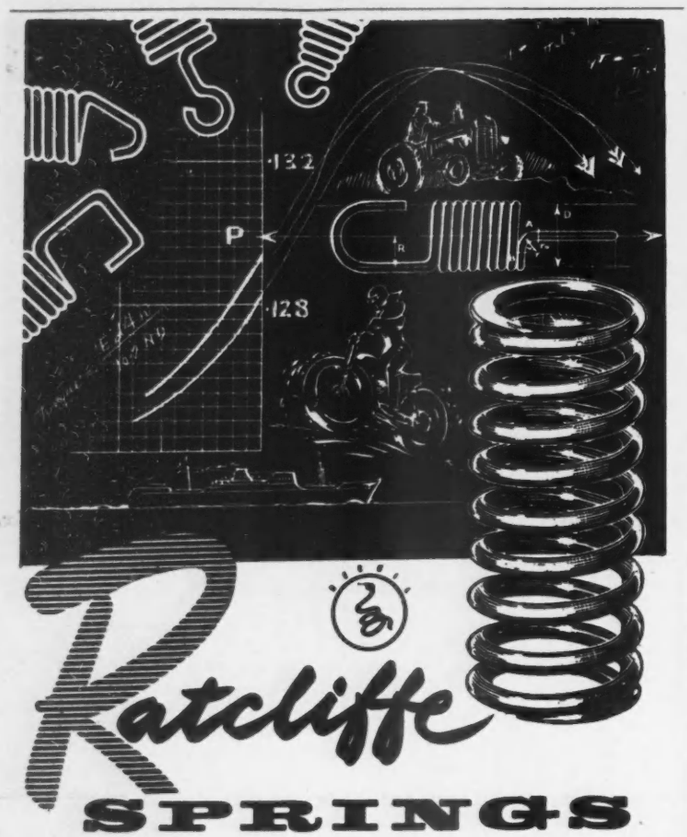

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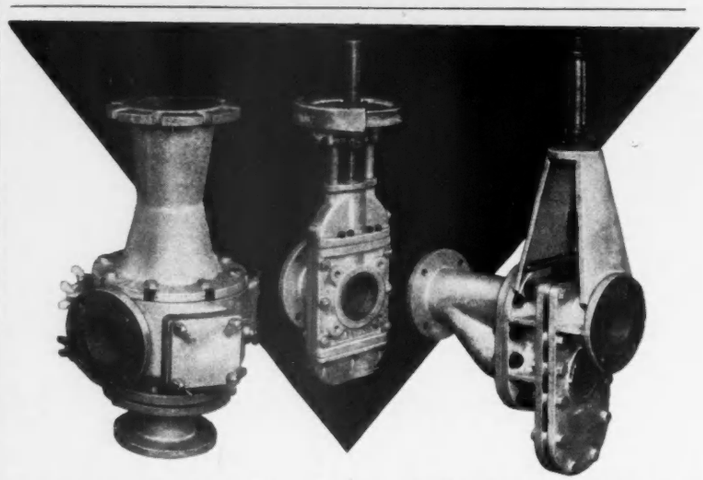

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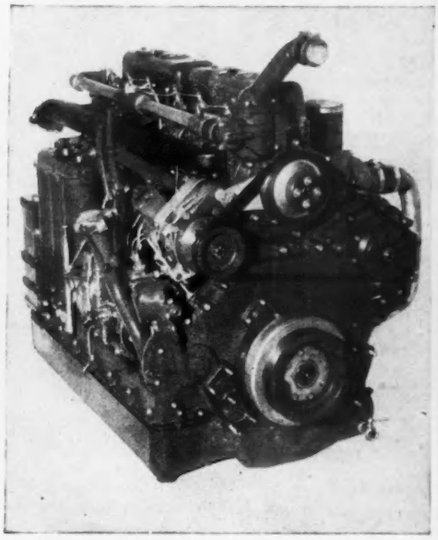
. . . in pump assemblies

Jet assemblies used in a SPEEDIVAC* Model 203 vapour diffusion pump during a test in which the pump operated for fifteen minutes and then air was admitted for five minutes. The jet assembly in the centre using MS703 silicone fluid had survived over 1,000 such cycles yet remained clean. The organic fluids in the other assemblies either failed or lost the ability to pump down to a high vacuum.

**Trade name of Edwards High Vacuum Ltd.*



MS

SILICONE FLUIDS

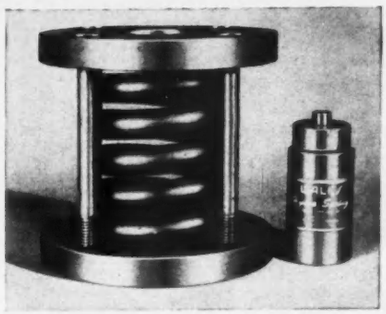
ensure peak performance over a wide temperature range

SILICONE FLUIDS are colourless, inert liquids ranging in viscosity from 0.65 to over 1,000,000 centistokes. They are heat-stable, resistant to oxidation and show remarkably little change of viscosity over a wide temperature range compared with other fluids. These properties make them excellent media for damping and hydraulic fluids, high temperature oil baths and special-purpose lubricants.

Silicone fluids are very resistant to shear breakdown. For instance, after 100 hours operation involving 18,000 cycles in a hydraulic system operating at 1,500 p.s.i. petroleum oil suffered a 50% decrease in viscosity. A MS 200 silicone fluid, after 500 hours of the same treatment had decreased in viscosity by only 15%.

. . . in torsional vibration dampers

This supercharged, six cylinder Rolls-Royce four-stroke diesel engine develops 275 h.p. at 2,100 r.p.m. The nitrite hardened crankshaft has seven main bearings and is equipped with a HOLSET torsional vibration damper which uses a high viscosity MS 200 fluid as the damping medium. The excellent shear stability of the silicone fluid as well as its good viscosity temperature characteristics make it highly suitable for this application.



. . . in liquid springs

A steel coil spring and a liquid spring of equivalent performance are shown. The liquid spring contains a silicone fluid which is highly compressible, will show little change in viscosity over a wide temperature range and will not break down even at high temperatures.

You are invited to write for full information about the properties and applications of silicone fluids. Literature on the many other MS silicone products including rubbers, resins, lubricants, compounds, electrical insulants, release and antifoam agents, is also available on request.

MS

TBW/MS 106

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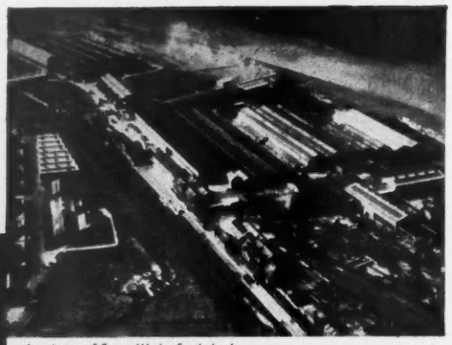
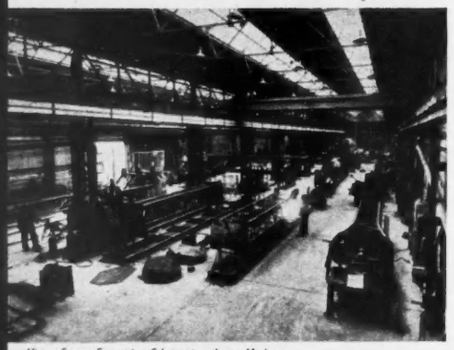
PIPE

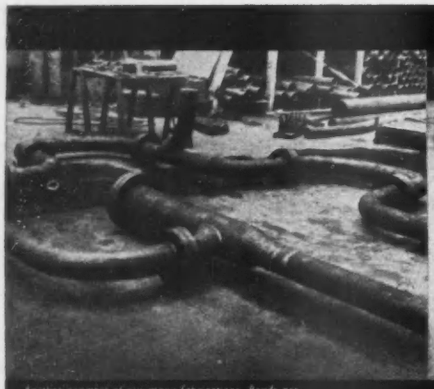


Aerial view of Crown Works, Sunderland

World famous for every kind of pipe fabrication in a wide variety of materials, STEELS and LOW'S are producing installations of exceptional quality and accuracy – for the marine, chemical and oil industries, the great nationalised industries, and atomic energy projects.

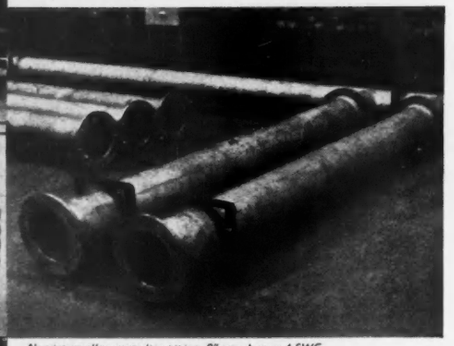


View of one of our pipe fabrication shops. Modern manipulators in foreground.



Another example of our many fabrications. Bends are machine made cold and unfilled, and stress-relieved.

Condensate coils fabricated for Admiralty.



Aluminium alloy cargo line piping, 8" nom. bore x 4 SWG thick, flanges ½" thick.

Pipe layouts are speedily prepared from site measurements and drawing details, backed by comprehensive metallurgical and testing laboratory facilities. Fabrication methods include all new and established principles of manipulation, welding, flanging and screwing in all materials normally used in the manufacture of tubes. Fabricated to British and American standards.

Special mild steel pipework for high pressure hot water process circuit.

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Modern well appointed mechanical laboratory ensures a high standard of prefabrication.

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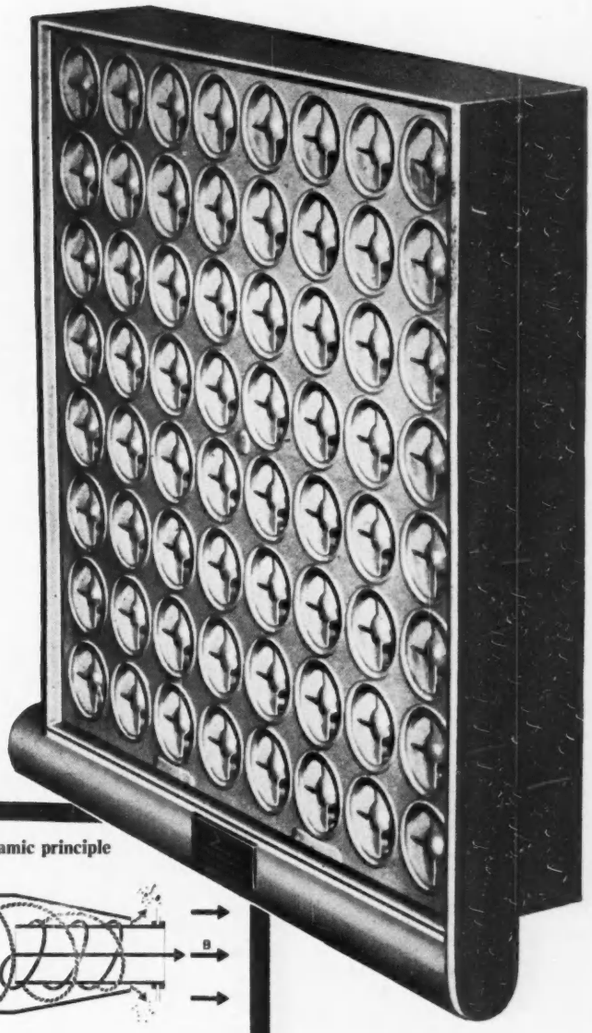
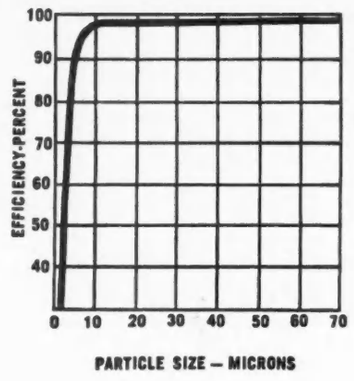
Engine air filtration without maintenance

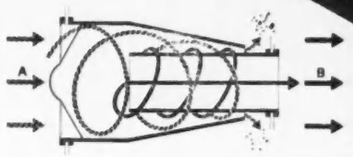
Reciprocating engines and air compressors attain their higher efficiencies through the use of smaller working clearances and relatively high speeds of revolution. Clean air, essential to such high performance machines, is reliably obtained at low cost through Rotonamic filtration.



Graph of Rotonamic efficiency percentage plotted against dust particle size



The Rotonamic principle



Air entering a Rotonamic panel at A is centrifuged at speed by the helical vanes. 10% of the air conveys dust to the bleed-off tube at the base of the panel. The remaining 90%, cleaned and filtered, reverses direction, enters the tube and exits at point B.

The illustration shows a Rotonamic panel comprising multiple static vanes which impart a whirling motion to the air entering the panel. The dust is centrifuged from the air and is bled off to atmosphere or dust bin.

Rotonamic air filters are self-cleaning and have no working parts to wear. These filters are extremely efficient and easy to maintain. Please write for leaflet FRC9.

Rotonamic filters are made in England by Intermit Limited

for high efficiency at low cost . . .

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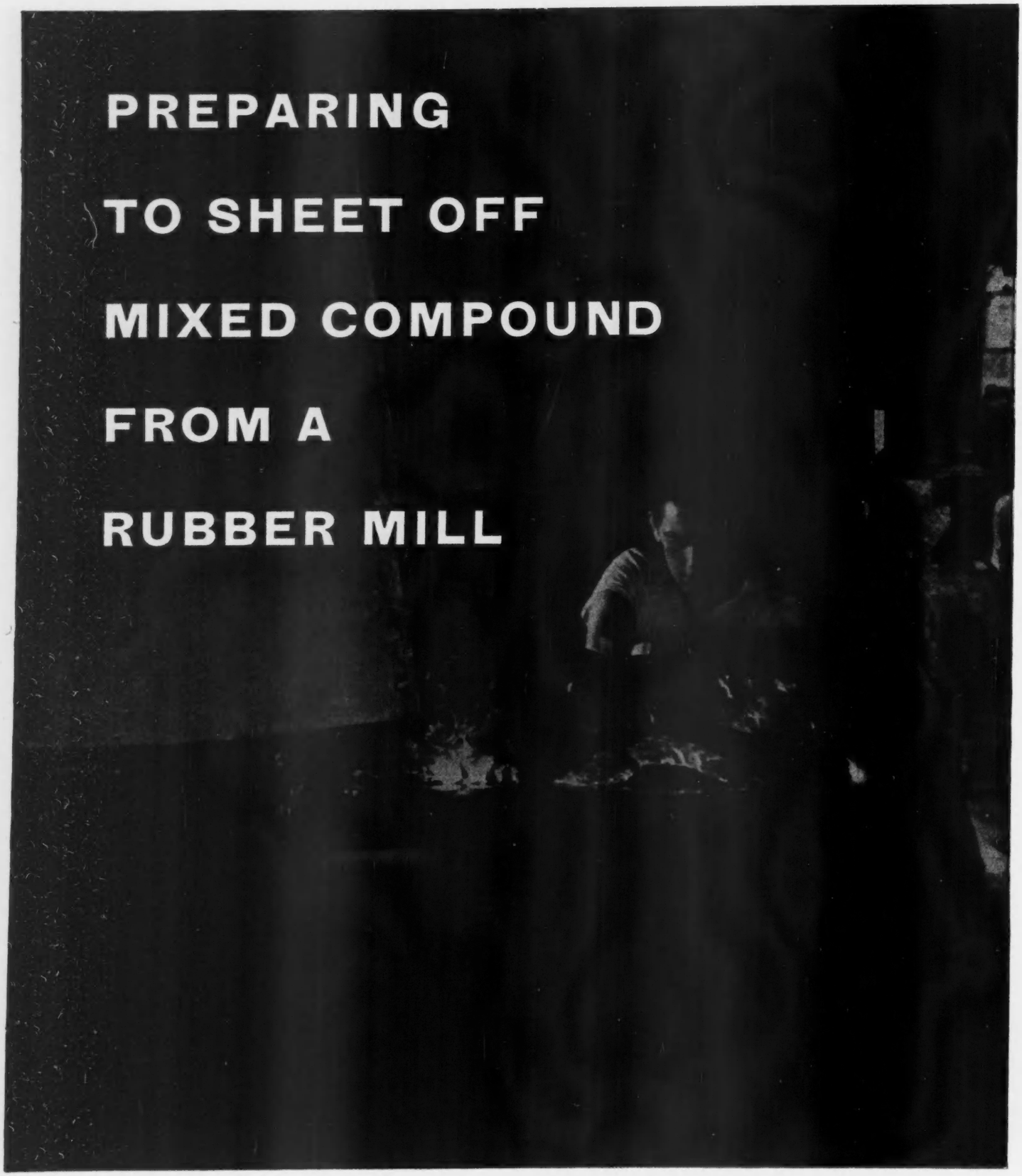

Whilst this is an operation common to any rubber mill, our study seems particularly and happily to catch the spirit of EMPIRE RUBBER — RUBBER BONDERS. Over a ton of mix an hour is handled by this operator and here he is seen adding the sulphur to the mix. This requires a high degree of skill, for good dispersion is essential. The take-off conveyor behind him duly carries away the product of his work for cooling, slabbing and storing.

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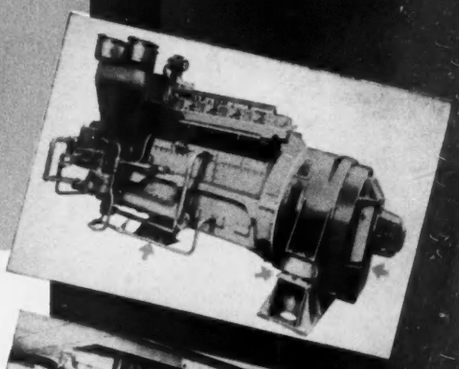
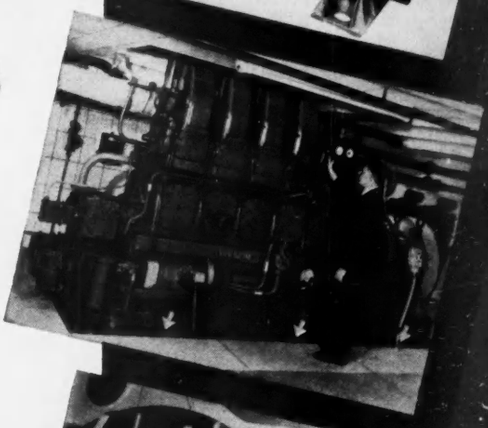
Cushymounts

Patented





LARGE DEFLECTIONS
for Wide Range of Loads

Cushymounts, based on wide and intensive experience of vibration insulation, provide the large deflections essential for the successful isolation of low-frequency vibration from heavy machinery. A single Cushymount supports as much as five tons and can be adjusted to give any required deflection up to ¾" for loads of one to five tons.

Integral Buffering

Cushymounts give the designer a complete mounting system. Despite their unusually high deflections no separate buffers or control links are needed, as movement in vertical and horizontal planes is limited to a pre-determined amount by positive means incorporated in the mountings. Cushymounts are, therefore, ideally suited to diesel locomotive engines and large generators for use on ships.

The illustrations on the right are: top, a Crossley generating set on three Cushymounts at the Dounreay Atomic Energy Establishment. Centre: 'English Electric' 4-cylinder diesel alternator on six Cushymounts and below: one of the three Cushymounts supporting the power unit on the Metropolitan-Vickers Bo-Bo locomotives for Eire.

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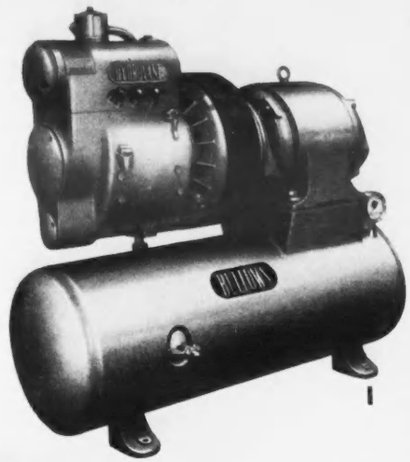
10 LICENCEES manufacturing Hydrovane Compressors *throughout the World!*



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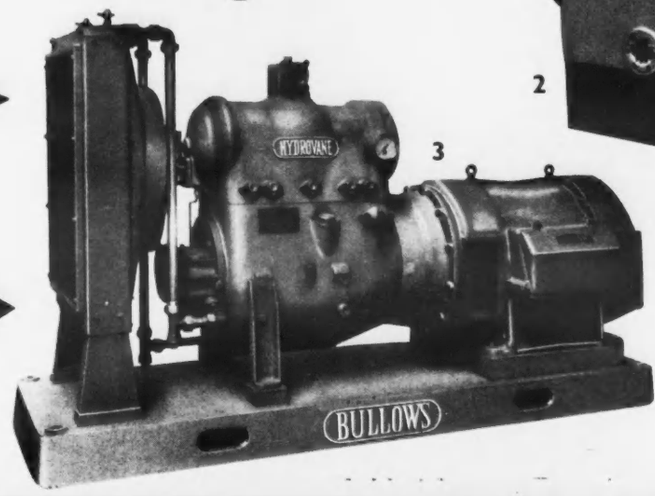

3

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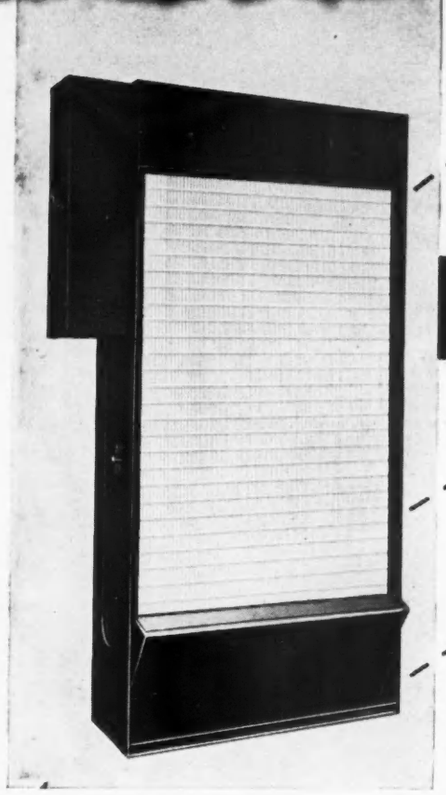

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For their Ruston Mark TA gas turbines installed in the Middle East, Iraq Petroleum Co., Ltd. specified Air Control-built AAF Multi-Duty air filters. The AAF Multi-Duty is an original design of viscous impingement filter embodying a unique and extremely efficient system of self-cleaning mesh panels. There is no oil "carry-over" and the filter is virtually everlasting even under the severest conditions.
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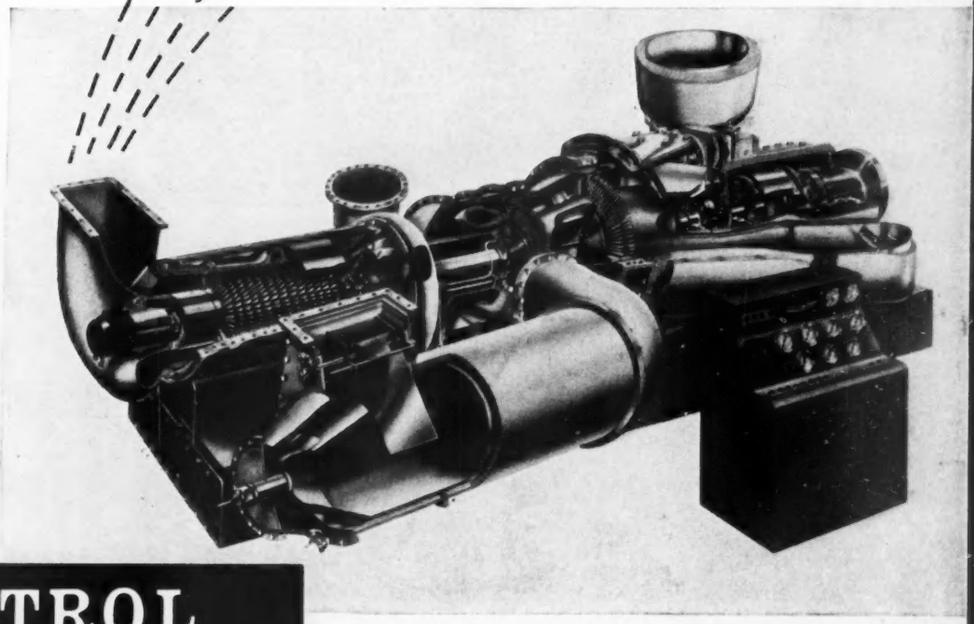

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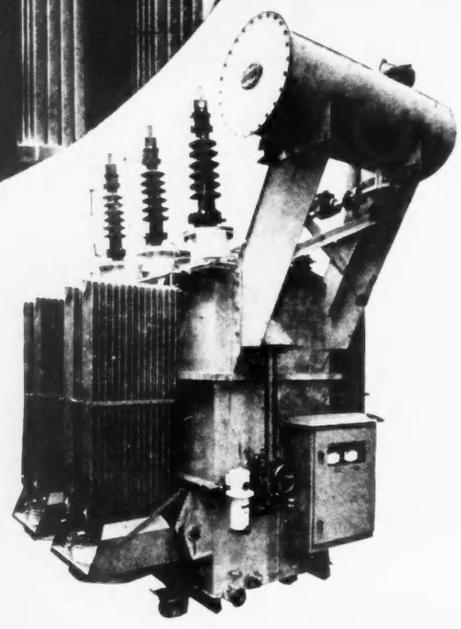
transformers

INDIA 7500 kVA 132/33 kV.
transformer for Madras.

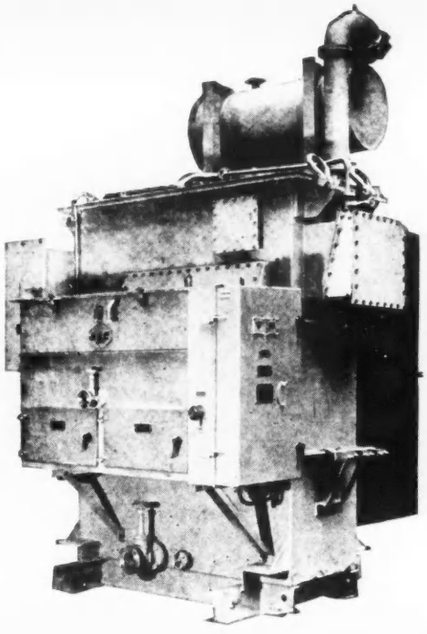


CHILE 5000/6250 kVA 66/16 kV transformer.

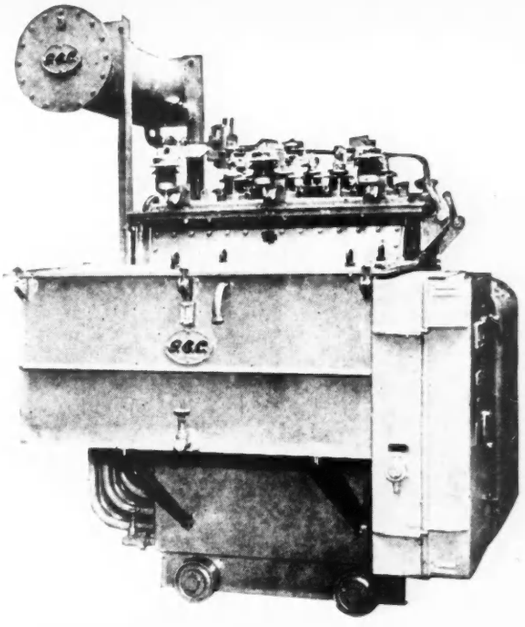
G.E.C. power

for the world

In lands as far apart as Canada and Chile — as India and South Africa — G.E.C. transformers are helping to bring the manifold benefits of electric power to the peoples of the globe. For the world has come to rely on the transformer equipment developed, manufactured and installed by the skilled technicians of this great organisation.



CANADA 2500 kVA 13·8/2·4 kV 60 c/s transformer fitted with on-load tap-changing switch for Niagara.



SOUTH AFRICA 2500 kVA 3·3/3·3 kV transformer fitted with on-load tap-changing switch for the Rand mines.

transmission equipment

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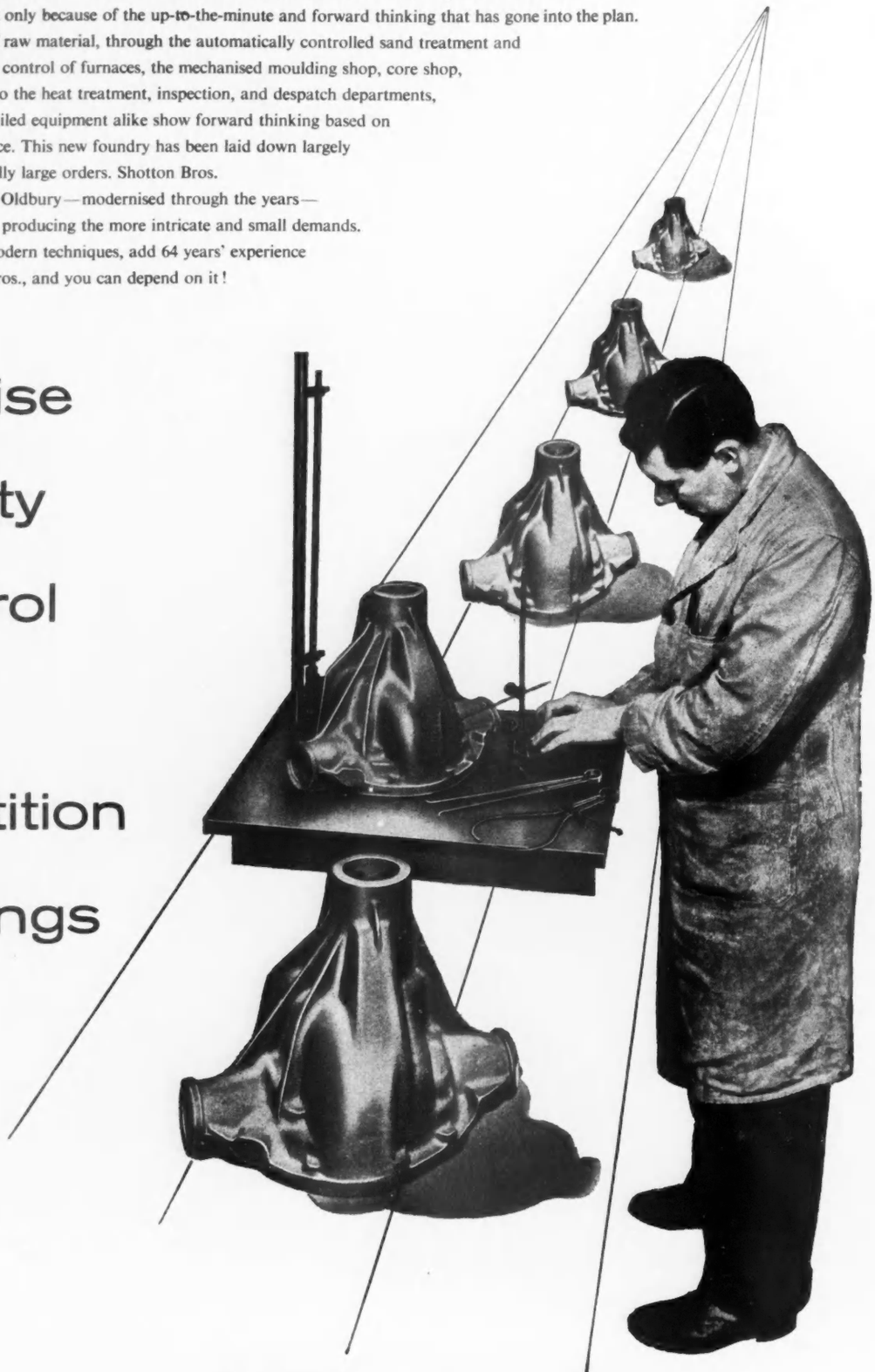
precise quality control of repetition castings



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3 automatic compound controllers give greater flexibility, more accurate control

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1 **BASIC CONTROLLER** : *for use wi… is not required.*

2 **CONTROLLER** : *incorpo… control internally.*

3 **CONTROLLER** : *wit… mounted externally …*

Set-up procedure is extremely simple — a particular advantage where it is necessary to close down the plant periodically, as resumption of automatic control can be rapidly effected. Further advantages are :

● **NO INTERACTION BETWEEN TERMS,** *enabling the controller to embrace wider plant characteristics …n are possible with interacting controllers.*

…CONTROL RESPONSE *generated*

…portional Band and Integral … are calibrated on the

…L can be methodically

…N UNITS *allow … and facilitate*

…s a two-term … Derivative or …troller with both units.

…, compact and …NCE PRINCIPLE of … and friction losses, the …ng high sensitivity.

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…e pleased to send you a copy of our fully …strated booklet No. R 35/2 on your request.

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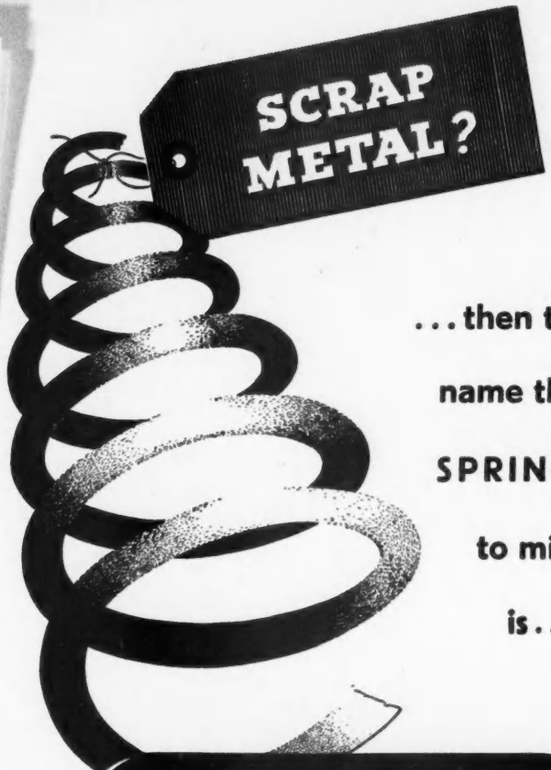

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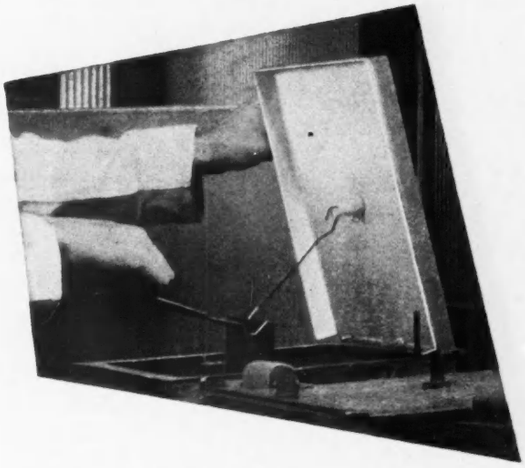

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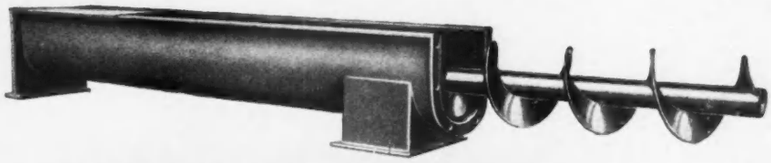

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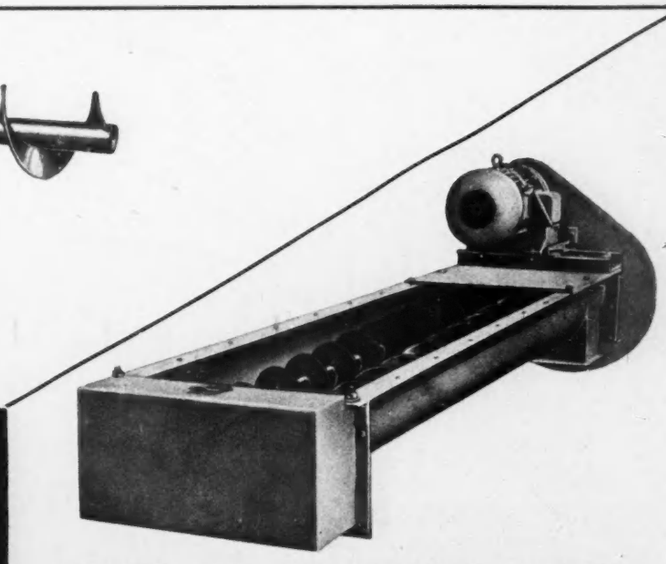

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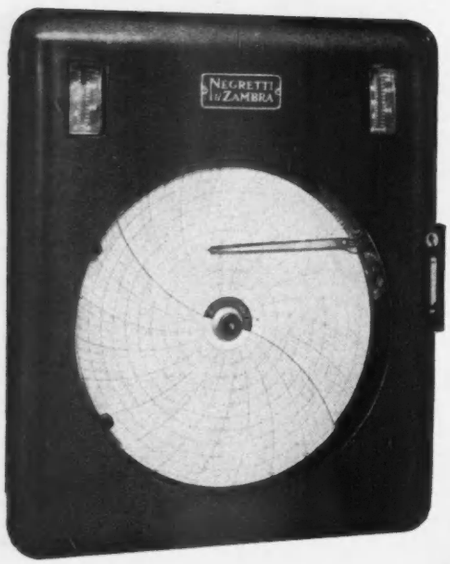

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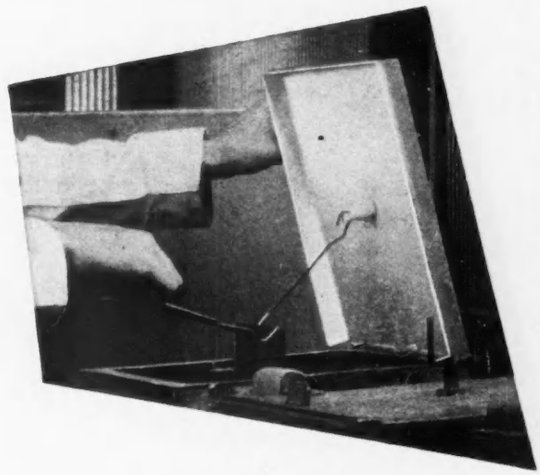

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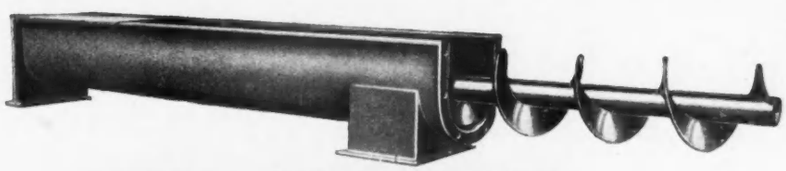

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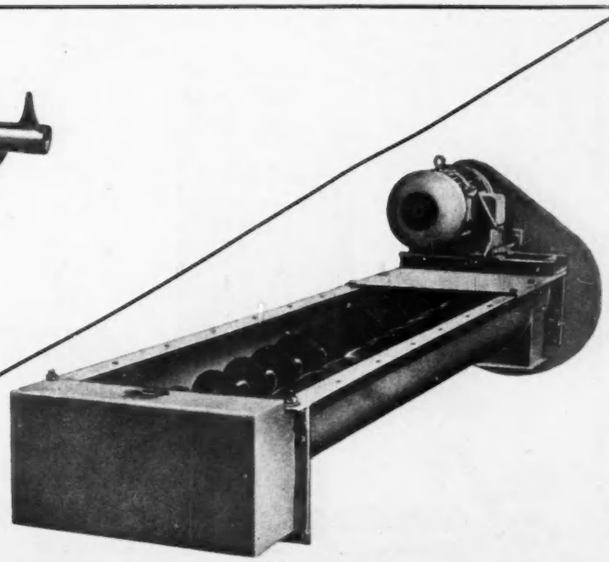

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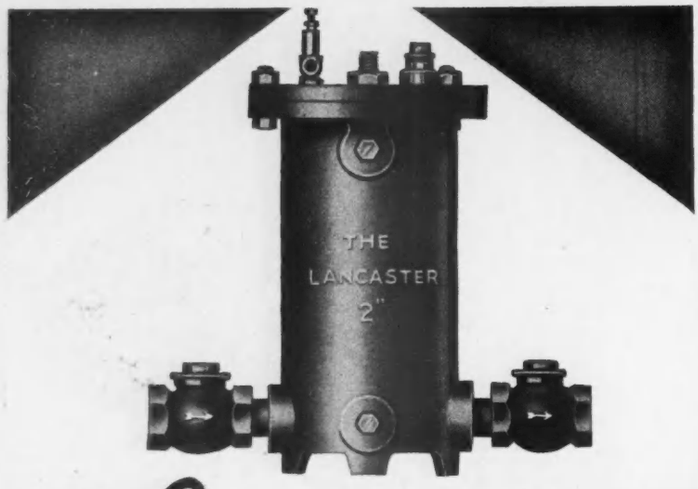

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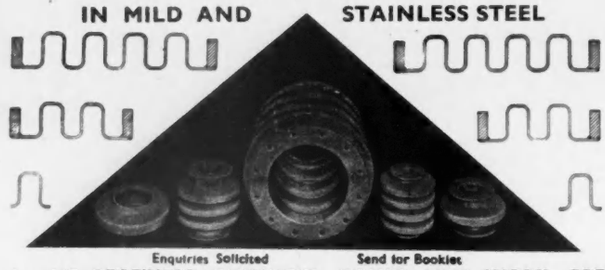

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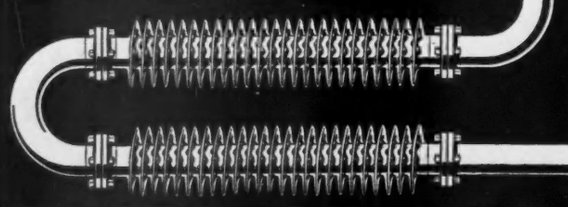

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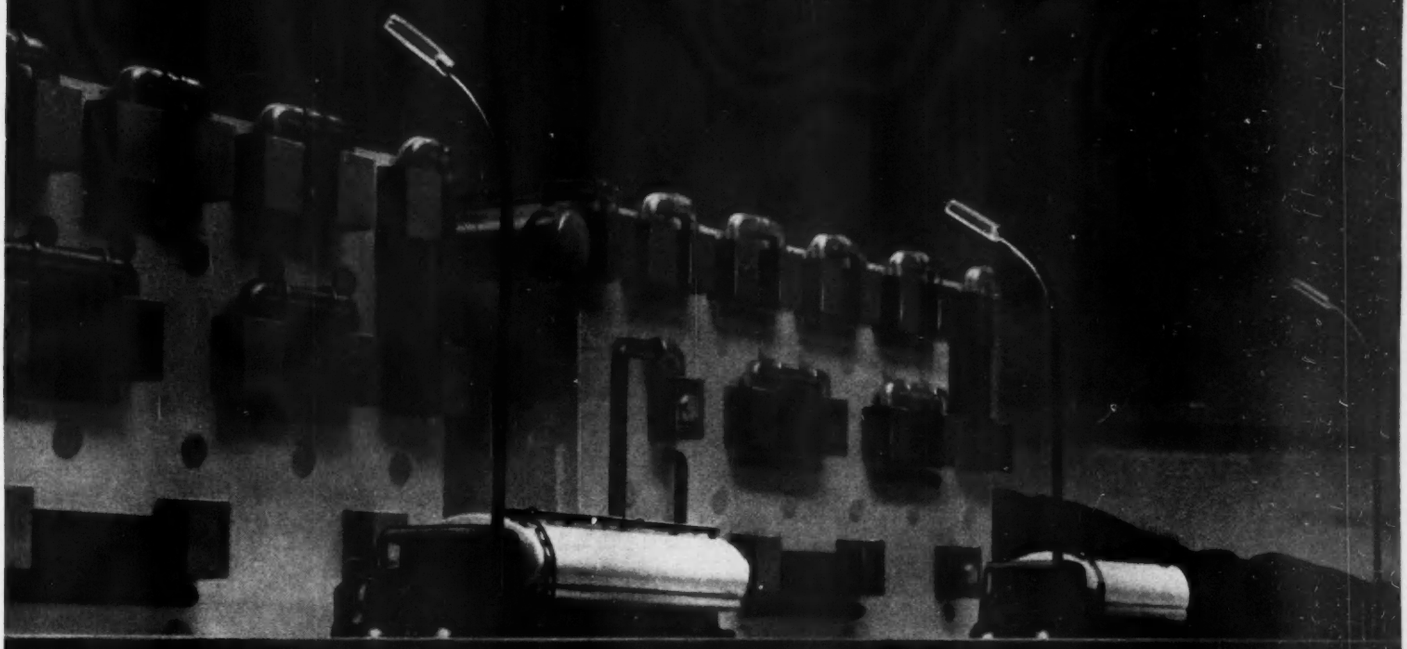

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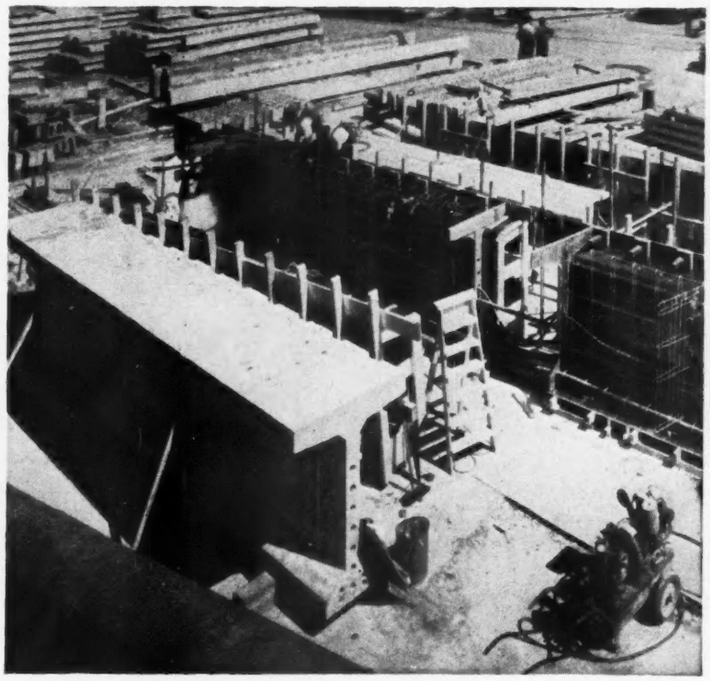

In left foreground of this view of the Hounslow Works of Concrete Limited is part of the precast reinforced concrete I-section beam for the Sidcup Road Bridge, Kent. Shuttering, reinforcement and duct-tubing for manufacturing further beams can be seen in the centre of the photograph.

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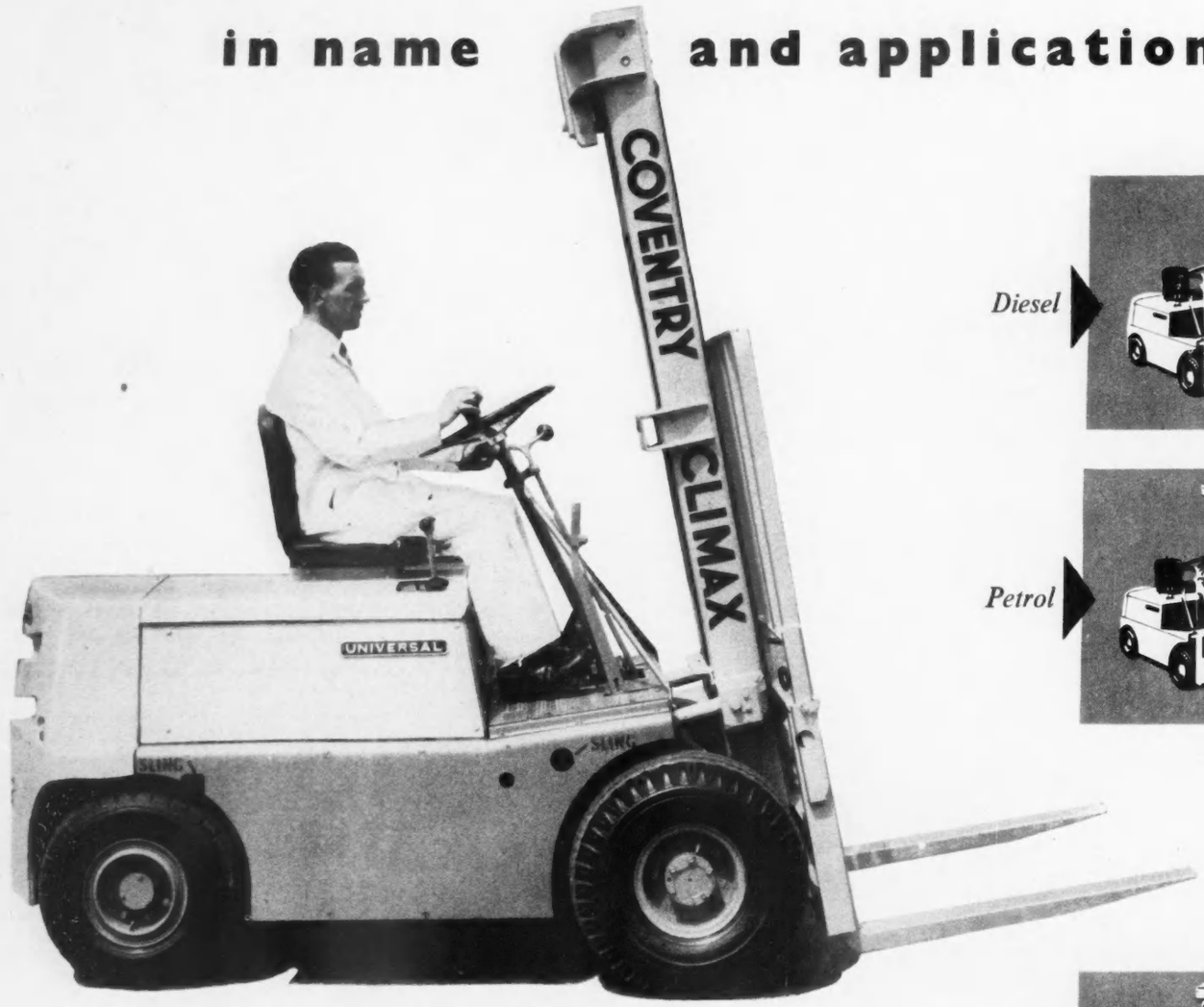
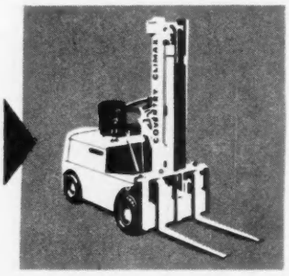
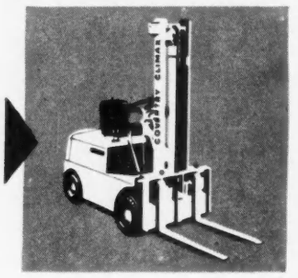


Diesel



Petrol



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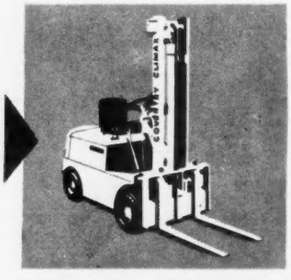

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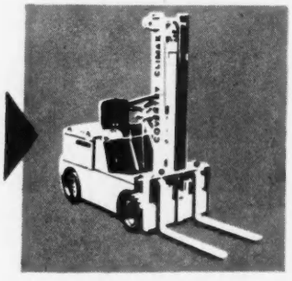

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THE ENGINEER

No. 5359 OCTOBER 10, 1958 VOL. 206

AGREEMENT ON WAGES

The resumed discussions on Thursday of last week between the Engineering and Allied Employers' National Federation and the Confederation of Shipbuilding and Engineering Unions resulted in the unions' acceptance of the employers' offer to grant a wage increase amounting to about 4 per cent. A similar settlement for workers in the shipbuilding industry was reached on Tuesday when the union confederation met the Shipbuilding Employers Federation. A significant factor about the negotiations on these claims is that they have taken much less time than those which preceded the last wage award in May, 1957. Moreover, at no time during the recent discussions does the atmosphere appear to have become quite so tense as it was eighteen months ago. That, of course, is as it should be. At the same time, consideration of the recent negotiations provokes the thought that seldom, if ever, do trade union executives seem to appreciate that there are occasions when an application for a wage increase must be refused by employers. Inevitably the unions are unwilling to take " no " for an answer even when the prevailing economic climate might become healthier for all if they did. The principal mission of trade unionism to-day, in fact, appears to be to secure higher wages with much the same grim determination as the trade unionism of past days when the disparity in living standards was far greater than it is now.

The recent negotiations were necessitated by a claim, submitted in June, for a " substantial increase," the amount in the mind of the unions evidently being not less than 6 per cent. That demand was refused by the employers who subsequently made an offer of an increase of the order of 3 per cent. The unions, however, rejected that offer and directed their spokesmen to seek further meetings with the employers " with the object of seeking an upward revision." The 4 per cent rise agreed upon is the outcome of those further meetings ; the union confederation may reasonably feel that it has made a fairly satisfactory bargain. On their part, the employers' federations have made concessions which, it is to be hoped, are a valuable contribution to the maintenance of peaceful relations in industries of prime importance to the nation's economic welfare. The increases granted follow the general pattern of wage settlements made this year. But it should be noted that the employers' offer contained no conditions of acceptance, nor did it suggest a standstill on wage claims, though the president of the Shipbuilding Employers' Federation emphasised that the cost of any wage increase must be met by economies in all shipyards. It is, of course, impossible to assess at all accurately at the moment the general effect of these latest wage increases on the affairs of the engineering and shipbuilding industries. Nevertheless, it may prove encouraging to bear in mind that, only a few days ago, the Prime Minister himself felt able to claim that this country was " back again in a very strong financial position " and that it was possible to " put the foot on the accelerator a little." To that claim the Prime Minister added his belief that the economy would respond. Meanwhile, the latest official statistics indicate that industrial production is falling a little and that exports—including the exports of some engineering manufactures—show a downward trend. In such circumstances, it is undoubtedly essential that the prices of British goods remain competitive with those of other countries. The best hope of the moment is that the wage increases gained this week by workers in the engineering and shipbuilding industries will serve as something of an incentive to greater efficiency and better productivity.

CLEANING THE AIR

Not such a very long time ago it was common practice in the towns of Western Europe to dispose of sewage into open street gutters. To-day it is unthinkable that anyone should adopt that practice. The National Society for Clean Air which held its annual conference at Llandudno between October 1 and 3 this year, hopes that in the not too distant future it will similarly become unthinkable to discharge smoke and other impurities into the atmosphere. A big step towards the attainment of that ideal was taken by the passage through Parliament of the Clean Air Act in 1956, and the coming into force of all its clauses on June 1, 1958. But, as Dr. Lessing, President of the Society, stressed, there is no excuse for the Society to rest on its laurels. It has, he said, " sown the seed," but the Clean Air Act is not the fruit but " a delicate plant which needs assiduous tending and fertilising to bring it to final fruition." This view of the situation is confirmed by a study of reports that were presented to the Conference from various areas of the country. These reports showed an encouraging degree of promise but not yet very much performance in implementing the Act. They also revealed the existence of certain difficulties. Many of those difficulties were anticipated. More education is needed in some areas, for example, before the public will appreciate how much smoke originates from domestic premises. Doubt is felt in some places about the adequacy of supplies of smokeless fuels. In mining areas, because of the distribution of concessionary coal, there is hostility to any suggestion for using smokeless fuels. The scale of the problem of replacing existing unsatisfactory fuel-burning appliances in domestic houses is in some places daunting and made more complex by questions as to how long existing sub-standard properties, whether scheduled for demolition or not, will be allowed to stand. There is a shortage of qualified Public Health Inspectors. Furthermore, there is the difficulty that the creation of smokeless zones or smoke control areas benefits not those zones or areas so much as the regions down-wind from

them. Thus, it would be helpful if action under the Act could be undertaken on a regional basis rather than by individual local authorities. But though local authorities are willing enough to set up joint advisory committees, it is a different kettle of fish to get them to set up joint executive bodies, for that or any other purpose.

But, perhaps—it is a point that we have stressed before—the predominant aspect of air pollution which must continue to worry the Society is that of sulphur emissions. The Clean Air Act is concerned only with smoke, grit and dust, broadly that is, with dirt in the atmosphere. But it has nothing to say about sulphur. Yet, as Dr. Lessing pointed out, the weight of sulphur dioxide discharged into the atmosphere is more than twice that of smoke, grit and dust combined. Through its oxidation to SO_3 and combination with water to form sulphuric acid, it is destructive to buildings and its effects upon human beings, not to speak of soils and vegetation, though quantitatively almost unmeasured, must certainly be deleterious. Even though the present Act were being implemented with all the vigour for which the Society could possibly hope (which is not true), there would still remain in the problem of sulphur emissions a complete justification for the continued existence of the Society. Additionally, it can be seen that as older problems of air pollution are beginning to be energetically attacked, new problems are being created. There is, for example, the problem of engine exhausts, particularly of motor vehicles in built-up areas, and the matter of the possible discharge of radioactive dust or gases from nuclear plants needs to be constantly watched. It is not and has not been the Society's role to undertake the scientific and technical work of research which attack upon such problems demands ; and the formulation and co-ordination of such work should be the task of the Clean Air Council set up by the Act. The object of the Society in the future as in the past must be to tell the public what is going on, to explain why it should go on or why it should be extended and to press the point that the nation will prosper the better by having pure air. For, without the support of public opinion, the Clean Air Act or any other Act of the future must prove abortive.

HAIL THE COMET !

Four and a half years ago a de Havilland " Comet " aircraft fell out of the skies near Elba ; another suffered a similar disaster near Naples three months later. Investigation showed that failure by fatigue of the pressurised cabin was the cause. So ended what had seemed until then a very successful experiment in the use of jet engines for passenger-carrying aircraft. The affair was tragic for the de Havilland company. It had produced this jet aircraft years ahead of any competition and might justly have expected an immense reward for its initiative through the progressive development of the design for different classes of service and through large sales to many different airways. Had fortune smiled the history of the " Comet " might have been as much a success story as that of the " Viscount." Sadly, we doubt if it ever can be now. For only miraculously can the years that the locusts have eaten be recovered. Such miracles do not happen nowadays. Yet it is a delight to everyone that they can congratulate the company upon being the first in the world to have its aircraft setting up a transatlantic jet passenger service. Officially there has been no race with the Boeing company of America to do so, yet we and every one else in this country are delighted that it is with a de Havilland " Comet IV " aircraft that the thing has first been done. It is, however, to be noted that the " Comet IV " was not designed as a transatlantic aircraft and it seems therefore improbable that it will be able to maintain itself competitively in that service for very long against other jet aircraft now under development or even perhaps against derivations of the " Boeing 707 " with which it will soon be in competition. There are, however, other services in the B.O.A.C. repertoire for which it seems well fitted. The " Comet " of course, never was a complete failure. Years before any other aircraft operator, it enabled B.O.A.C. to gain experience of the peculiar factors relating to the economy of operation and maintenance of jet-propelled passenger-carrying aircraft. But the noon-day of what should have been its success has, we fear, been lost. There may, however, well be an Indian Summer to recompense the company that developed it for all the hard work and expense that has gone into the project. Everyone, not excluding competitors of the de Havilland company, will hope so.

MEMORANDA FOR " MECHANICALS "

The *Chartered Mechanical Engineer*—the journal of the Institution of Mechanical Engineers—contains in its October issue a number of interesting reports and announcements. First in importance are reports of Conferences of the Engineering Institutions of the British Commonwealth held in March in Australia, and of the Engineering Societies of Western Europe and the United States of America held at the end of April in New York. But we prefer to defer comment until the texts of various recommendations and resolutions adopted at these conferences, but awaiting ratification by the councils of the bodies concerned, are made public. It is in other announcements that we are here particularly interested. One of them relates to the day of the week upon which ordinary meetings of the Institution are held. Within the memory of all living members it has been Friday. But beginning with the 1959–60 Session it is to become Wednesday. The change is partly linked up with the fact that many offices and works in the London area are not nowadays open on Saturday morning. Wednesday has been chosen because the " Civils " hold meetings on Tuesdays and the " Electricals " on Thursdays. It is obviously desirable to avoid a clash. It does not seem to us important that a tradition of meeting on Friday should be preserved and it is very possible that a majority of members will prefer Wednesday meetings. Next we note that the " Mechanicals " are to fall into line with certain other institutions and societies in making a little ceremony of the admission of new corporate members. Even if such ceremonies do nothing more than combat the tendency to regard the major institutions as merely qualifying bodies they do good. For too many members seem to forget that in earning the right to place A.M.I.Mech.E. after their names they have also by implication admitted that they have certain responsibilities to support the Institution !

Lastly—and with great pleasure—we note that the council has decided " to explore the possibility of holding the Summer Meeting next year in Switzerland." Zürich would be the chosen city and none could be better for a party of engineers and their ladies, as there are engineering works with a diversity of products within easy reach and delightful excursions of various kinds available for the ladies. We hope that, despite the form of words used by the council, there is, in fact, no doubt at all that the Institution will take its members to Zürich next year. Judging by the tone of the announcement the staff of the Institution seems to feel somewhat in the dark about the

likely attendance. But, of course, it is in the dark ! The Institution goes abroad so seldom that there is no means by which its staff can judge at all securely what the attendance is likely to be. Only once since the war ended has the Institution ventured abroad and then only as far as Holland. But now that a European Economic Community is coming into being and a Free Trade Area is likely to develop around it, we hold it essential that the Institution should go abroad for its Summer Meetings at much more frequent intervals.

"STATISTICS ON CONSTRUCTION"

It has always been difficult to find statistics about the activities of the civil engineering industry in this country. Over the past few years we have on occasion given some indication of the principal statistical data governing its activities in our annual civil engineering reviews, published in January, when whatever official figures we have been able to find have been quoted, and further information has been culled from our *Tabular Summary of Civil Engineering Contracts*. But this data has been rather patchy, so we welcome the Federation of Civil Engineering Contractors' latest publication, which is entitled *Statistics on Construction*. All the available statistics about the "construction" industry have been brought together in this booklet, which thus redeems a neglect almost incomprehensible in this age of statistic-gathering. The total output of the "construction" industry—that is, the building and civil engineering industry—was £2250 million in the last full year (1957) quoted in the booklet. It is virtually impossible to separate "building" from "civil engineering" in compiling these figures, though it is considered that civil engineering contractors probably achieve about a quarter of the total output just quoted. However, totals are given for output in the following divisions :— Housing, educational building ; industrial construction ; roads ; power stations ; opencast coal ; and work overseas. So with these and other figures a fair idea of economic trends in the industry can be gained. Figures of more general interest covering the industry as a whole show that 47 per cent of the country's capital investment goes into constructional work (i.e. £1570 million. The rest of the total quoted above is repairs and maintenance). Further, the construction industry accounts for 6 per cent of the gross domestic product, and 6 per cent of the total civil employment. Its profits, however, are only 3 per cent of the total made by all companies.

ENGINEERING SOCIETY MOVES TO LONDON

From time to time we receive news of the removal of firms or societies from one address to another. Usually the operation can be compared to that of an indoor gardener repotting a plant. The firm or society has grown so far that further growth will be restricted unless larger premises are obtained. Usually these new premises are found close to the old or at least within the same industrial area, and nothing but good can be expected from the move. Sometimes, however, something more radical is done. The gardener not only repots the plant but settles it into an entirely new situation in the belief that it will be better suited by the new locality. The firm or society moves from one town to some other and distant place. Amongst notable bodies which have done so in the past is the Institution of Mechanical Engineers, which was initially founded in Birmingham and some years later transferred to London. Now we have news of another such move. Within the last month the Incorporated Plant Engineers has changed its address from Solihull in the Birmingham area to 2, Grosvenor Gardens, London, S.W.1.

There is always danger to societies, as to plants, in such transplantation. It is always possible that the "gardener" may have misjudged the strength of what may in fact be a delicate growth and that it may wither and die in its new situation before it becomes established. But we see no signs of that kind of delicacy about the Incorporated Plant Engineers. It is, of course, a very young society. It originated during the second world war when engineers in charge of large American excavators imported for working open-cast coal met together to exchange information and for mutual help. Later engineers in other fields began to join in, and in September, 1946, the society entitled Incorporated Plant Engineers came into being. Within a year of incorporation there had been set up branches at London, Birmingham Manchester, Leeds. Newcastle, Glasgow and Bristol, and by 1954 there were no less than eighteen branches in Britain and one overseas. Membership, which was a mere 120 in 1946, has now increased to nearly 4000, some 500 of whom are stationed overseas. The members include engineers in charge of plant of very diverse character. We cannot for one moment believe that so vigorously flourishing a plant will prove unable to survive any slight shock there may be by the transference of its headquarters from Solihull to London.

The Engineer — 100 Years Ago (OCTOBER 8, 1858)

"ISTHMUS OF SUEZ CANAL."

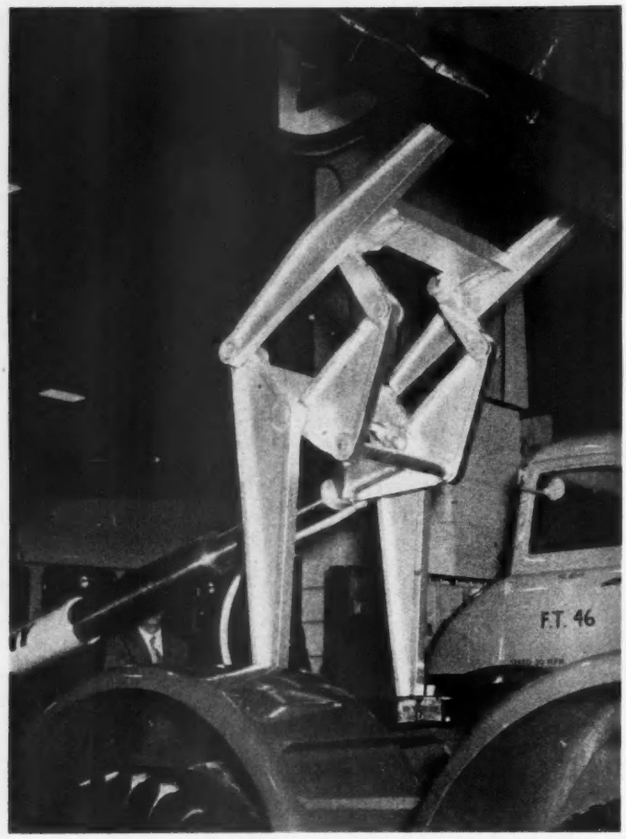
"Many of our readers may possibly believe that the Suez Canal scheme was finally shelved after the opposition it met with a short time since, both in and out of Parliament, at the hands of Lord Palmerston, Mr. Robert Stephenson and others. Such, however, is by no means the case. The friends of the project are still as active as ever, and, indeed, every reverse they meet with only seems to stimulate them to fresh exertions. It is only two or three weeks since a pamphlet was published at the Hague, from the pen of F. W. Conrad, entitled 'The Question Stated,' and in which the subject is discussed at considerable length .... Our readers are already probably aware that an international commission, consisting of many eminent engineers, was some time ago appointed to examine into the question of forming a canal through the Isthmus of the Suez. This commission, the author of the pamphlet tells us, adopted a canal in a direct line, dug in the soil of the isthmus and fed by the waters of the sea.

"Whether the Suez Canal scheme be practicable or not, and whether it will 'pay' or not, are two very different questions. Any opinions upon these points are valueless, except they come from those who have minutely examined into the truth and falsehood of the various statements which have been put forward, or who have surveyed the country through which the canal is proposed to be cut. So far as we are able to judge from the data supplied in the pamphlet before us, as well as that which has previously appeared, we strongly incline to the belief that the project is feasible. As regards the political phase of the question, it is out of our province to speak, but in these days of free trade, opposition to the scheme on political grounds seems retrogressive. In the event of the canal being formed and navigated, the Cape would, no doubt, suffer ; but it is hardly likely that the world will stand still for the purpose of propping up that settlement."

Commercial Motor Show

No. II—(*Concluded from page* 520, *October* 3)

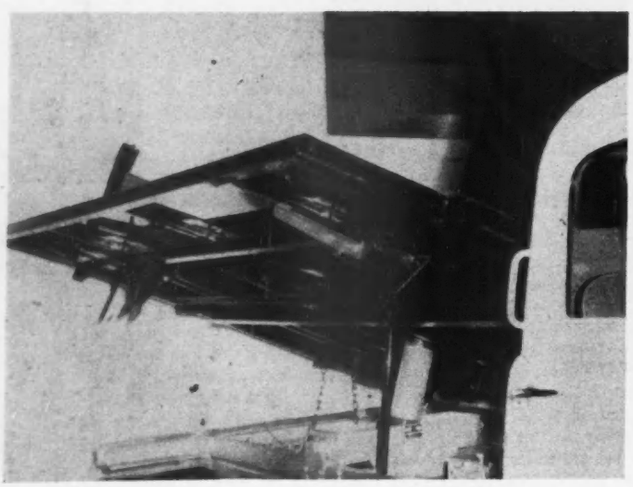
The Commercial Motor Show at Earls Court included a small proportion of vehicles from Czechoslovakia, France, Germany, and the United States. Air suspension appeared on passenger vehicles and, particularly, trailers, and has brought with it much use of telescopic hydraulic dampers. Many special-purpose vehicles, often built for individual customers, were to be seen, among them this large tipper with a single ram acting through a stabilising linkage. A new 18-*litre* 1900 *r.p.m. oil engine with a b.m.e.p. of* 163 *lb per square inch was announced.*



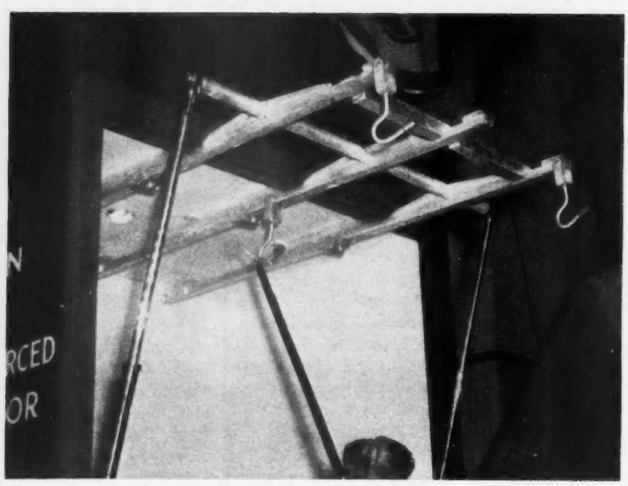
THE underbody tipping gear normally suffers from the disadvantage that the leverage of the lifting ram is least at the point where the moment of the load is greatest, i.e. at the commencement of a tip. This results in a very high initial ram effort, which is often directed mainly to pushing the body off the chassis backwards, and dictates an undesirably large space between the body floor and the propeller shafting to accommodate the ram and trunnions. A solution to these difficulties was demonstrated by Anthony Hoists, Ltd., on an Albion " Caledonian " chassis, as shown in our heading illustration. A very generously proportioned stabilising linkage is incorporated, and a pair of the subsidiary links extend into a three-dimensional component, to the apex of which the single ram is pivoted. When, as seen here, the linkage is extended, the ram is applying a backward moment to the bottom links through the lowest corner of the parallelogram geometry. But when the body is at rest on the sub-frame and the linkage is collapsed, the ram applies a forward moment to the upper links through the short rear sides of the parallelogram, and its thrust is opposed by the lower links in compression. This construction has allowed the body floor to be only 14½in above the top of the frame.

Another somewhat unusual tipper is the Telehoist equipment, illustrated on a Thames " Trader " chassis. This is a three-way tipper intended for use with mechanical road-making equipment, in which it is necessary to discharge into a hopper alongside the vehicle. It is therefore desired that the body sides shall not drop completely but lie in the plane of the floor so as to carry the load over the gap between tipper and hopper. Pivoted arms have been placed under the body which can be swung out to act as cantilevers and support the body side when the spring-loaded locking pins at the ends have been withdrawn. It can be seen that this method of supporting the side-board places less stress upon it than would chains to the corners. Another interesting detail of this body is that the floor ends in a round-down centred upon the side-board hinge line, so that there is not a gap between floor and side in which stones can be trapped.

A highly specialised loading device was to be seen on the stand of Autolifts and Engineering Company, Ltd. This was the Marsden " Solo-Loader " meat handling gear, illustrated below; it takes the

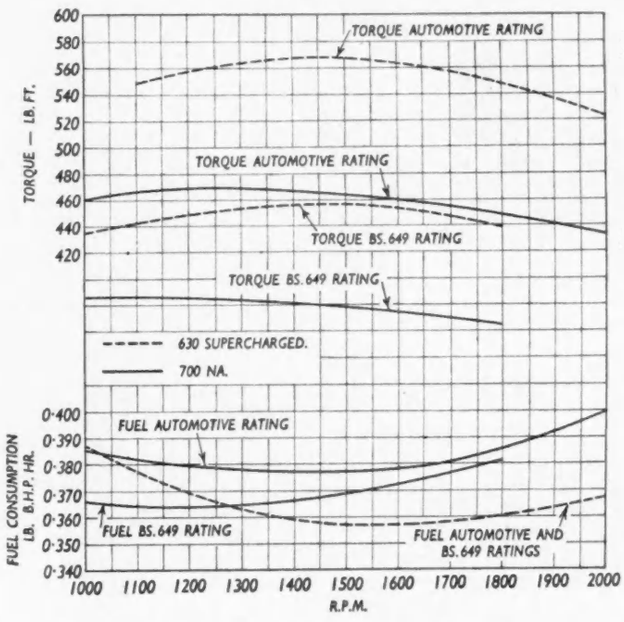


A three-way tipper intended for loading mechanical road-making equipment. In use, only the lower side-board would be extended



This meat loader raises the load from shoulder level to van roof height, when it can be run forward into the storage volume

form of an extension of the rails, in the roof of a van, from which meat is slung for hygienic transport, and the extension can be raised and lowered by hydraulic rams. To avoid running the engine when meat is being on- or off-loaded, an electric motor is used to drive the hydraulic pump. When the rails are hinged down, the hooks are brought down to shoulder height and can easily be removed from or placed on the rails. When the vehicle is in use, the loader can either rest vertically within the rear doors or be stowed folded forward under the fixed rails.



Long-stroke and turbo-charged versions of the 130mm by 130mm engine compared

Power Units

Obvious incentives to the use of more powerful vehicles have been provided by the increased legal maxima for gross weights and road speeds, and it was not surprising to note that a large proportion of the engines exhibited had been developed to higher powers. For a vehicle builder who does not intend to design a completely new vehicle for these duties, the most attractive way to increase the power is by overcoming the permissible engine speed restrictions. An interesting example of such a development is afforded by the Foden two-stroke, which in four- and six-cylinder forms now gives peak power at 2400 r.p.m.—100 h.p. and 150 h.p., respectively.

The development of the Mk. III engine from earlier models is mainly concerned with the crankshaft and bearing assembly. Whereas earlier models had white metal main and big-end bearings contained in heavy steel shells, the Mk. III engine has lead indium flashed copper lead thin shell bearings. The increase in the internal diameter of these bearings, due to the reduction in thickness of the bearing shell, has enabled the main bearing and crankpin journals to be increased in diameter, and these are now $3\frac{3}{16}$in and $2\frac{13}{16}$in respectively.

The immediate benefits of this modification are that the engine full-load speed is increased to 2400 r.p.m. and a very much higher lubricating oil temperature is tolerable, due to the change in bearing material, resulting in increased thermal efficiency. This, in turn, enables an oil cooler to be used in the engine cooling water circuit, and the advantage of this is that the jacket water is used to raise and maintain the lubricating oil temperature under starting and light load conditions. The wax-filled water thermostat controls both water and lubricating oil temperatures, the heat exchanger being " inside " the thermostat circuit.

The increased crankshaft speed has not caused the push-rod valve gear to be abandoned ; the camshaft is sufficiently close to the head for the valve bounce speeds to be very high, and, since the Mk. III engine has separate cylinder heads, the ability to remove one head without disturbing the crankshaft is more valuable than access to all the cylinders without disturbing the valve gear. The Mk. III has, however, a different camshaft. Nor has the engine changed to a distributor pump, although, as noted in No. I, both four and six lobe versions are now available from English sources ; the camshaft pump is apparently satisfactory up to even higher speeds than those now used, the lubrication of the camshaft and followers being now by engine oil—Supplement I — and no longer fuel. The hydraulic governor on the camshaft pump is, it will be recalled, fundamentally different from that of the distributor pump in that it has an amplifier stage.

These advances have given the two-stroke engines power-weight ratios of 10·1 lb and 8 lb per horsepower in the 100 h.p. and 150 h.p. versions. A point that is particularly worthy of note is that, we are advised, the torque curve has simply been extended to higher speeds, without any change in the torque available at lower speeds. This engine is, therefore, precisely what one might have expected a vehicle manufacturer to develop, a more powerful unit of the same size and weight driving into the same transmission. It should be noted that the alternative engine in the Foden chassis has followed the opposite trend of development (see page 182, August 1, 1958), and that while a " 6LX " will fit on the mountings of a " 6LW," it requires a new gearbox heavier than that common to the smaller four-stroke and the two-stroke.

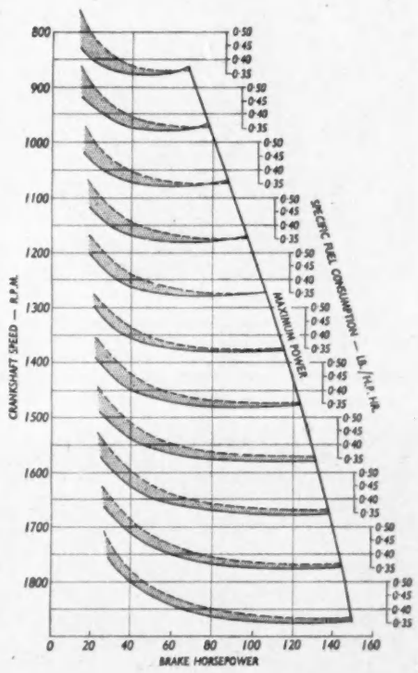
The two-stroke engine is perhaps favoured in respect of running speeds by the fact that the piston is on compression at every top dead centre, with a resulting improvement in connecting-rod stress conditions. Consequently, many four-stroke engine builders beside Norris, Henty and Gardners have chosen to increase the available torque, either by enlarging the swept volume or increasing the mean effective pressure. New engines exploiting each of these approaches were shown by Henry Meadows, Ltd., who have also uprated the existing engines in both speed and torque ; the (basically similar) four-cylinder, 330 cubic inch (" 4DC 330 ") and six-cylinder, 500 cubic inch (" 6DC 500 ") engines have been allowed an extra 100 r.p.m. to run at 2500 r.p.m., and have outputs of 100 h.p. and 150 h.p. respectively. Each has a peak brake mean effective pressure of 110 lb per square inch at 1400 r.p.m.

The four-cylinder version only has a distributor pump ; the four-cylinder unit also has a slightly better power-weight ratio (contrast the units of similar power above mentioned) the figures being slightly below and above 10 lb per horsepower, excluding electric auxiliaries.

The main lines of development, however, have sprung from the larger engine, the " 6DC 630," of which the basic version has been uprated from 130 h.p. at 1900 r.p.m. to 145 h.p. at 2000 r.p.m., with an increase in brake mean effective pressure from 100 lb to 103 lb per square inch at 1200 r.p.m. Having most components in common with this engine, a long-stroke version (130×143, instead of 130^2), the " 6DC 700," has the same governed maximum and peak torque speeds, developing 165 h.p. and 102 lb per square inch brake mean effective pressure. The main increase in brake mean effective pressure is seen in the turbo-charged engine, the " 6DCS 630," which has a peak of 129 lb per square inch at 1400 r.p.m. and yields 185 h.p. at the same governed maximum.

Neither enlarged nor supercharged versions of the four-cylinder variant, the " 4D 420," of 97 h.p., are available, since they would be in the same power class as the small 2500 r.p.m. engines.

The turbo-charger used is a Holset/Schwitzer component, giving a peak pressure ratio of 2·1 : 1 and not exceeding a turbine inlet temperature of 550 deg. Cent.



Comparison of part load performance of 4·5in bore and 5in bore by 5·5in stroke engine with the same full load torque

Performance curves for the 165 h.p. and 185 h.p. engines are reproduced here ; it is worth noting that their weights differ only slightly, 1850 lb and 1900 lb without electrics.

A significant feature of these curves is that the specific consumption of the blown engine is the same at two markedly different rack settings, i.e. the addition of extra air as

DETAILS OF REAR AND FRONT SUSPENSIONS

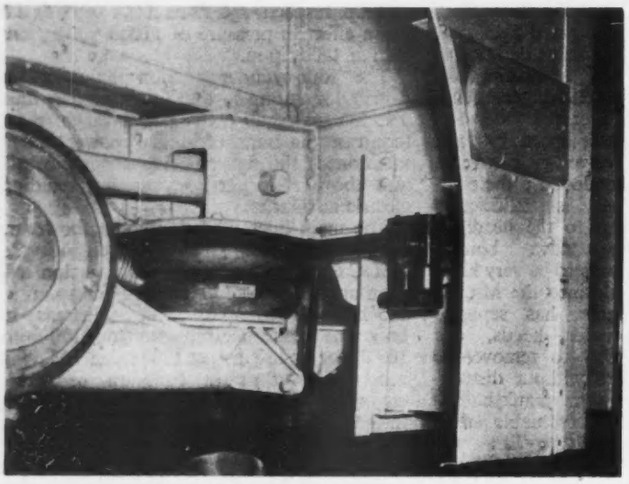


Fig. 1—The rear suspension of the "Olympic" on the M.C.W. stand uses the air tanks as beams to spread the vehicle weight over four points. The lower trailing links pick up the front end of these beams, and a Panhard rod the rear of one

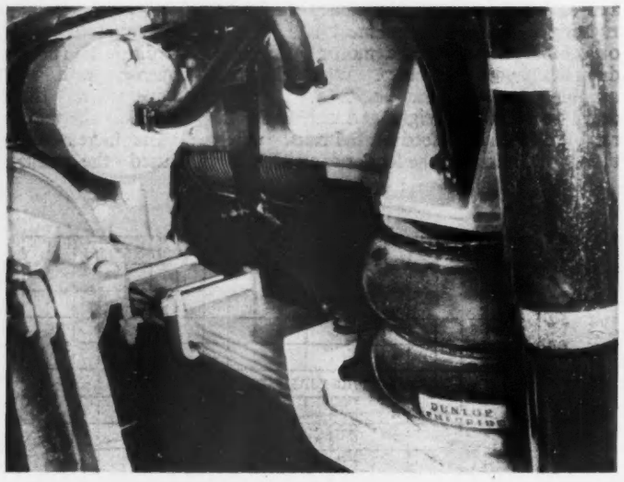


Fig. 2—The front suspension is traditional, with air bellows used to give a constant platform height. Notice the remote location of the bellows and tank, and the linkage to limit rebound travel. In the foreground is a telescopic damper

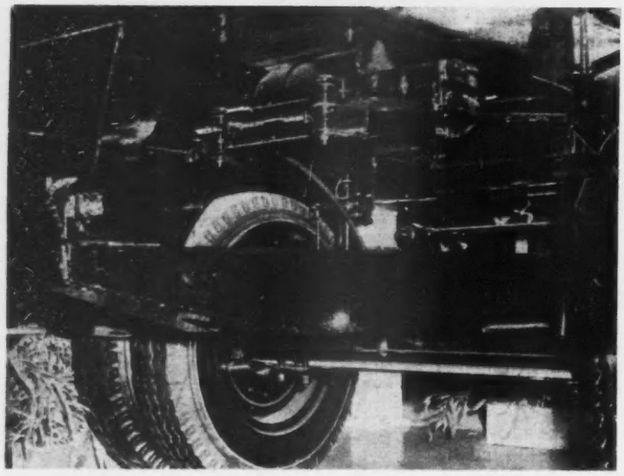


Fig. 3—The air sprung Hands semi-trailer is unusual in that it has not been designed for minimum roll and is correspondingly simple: it can be seen here that the roll centre is at about the height of the tyre. The off-side telescopic damper and Andre single-convolution bellows can be seen beyond the level control valve

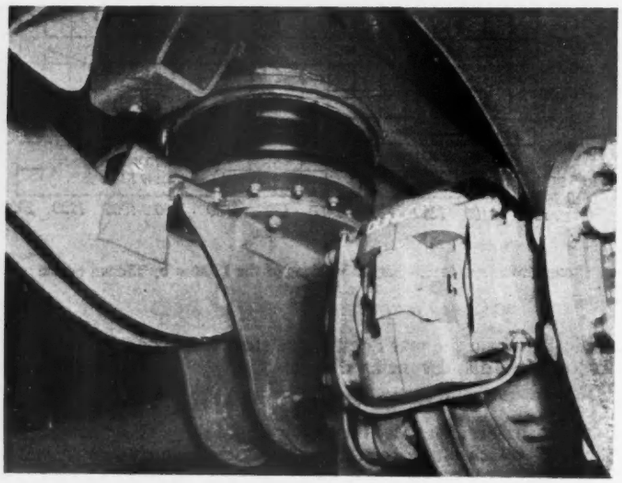


Fig. 4—The front axle of this Dyson four-wheeled trailer is located by trailing arms which are pivoted in the pitch plane to reduce the roll stiffness: the brake reactions are taken through the rubber buffers seen here. The weight transfer at the rear is made correspondingly high by parallel trailing arms clamped to the axle. Notice the use of disc brakes

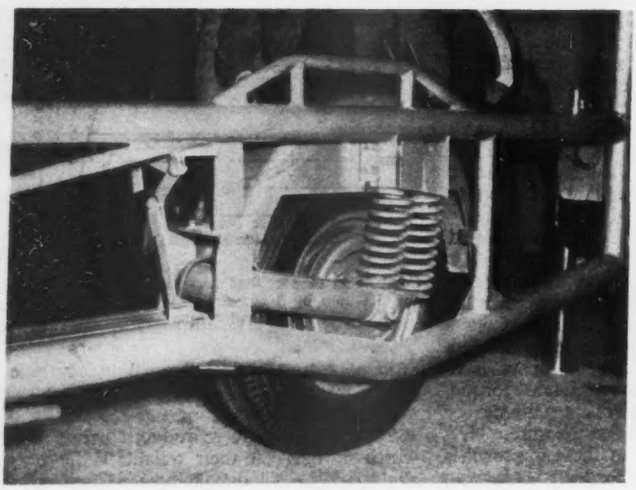


Fig. 5—Trailing arm instead of swing axle geometry can be employed on the f.w.d. "Tempo 1500," and this allows the body to occupy the entire space between the chassis members

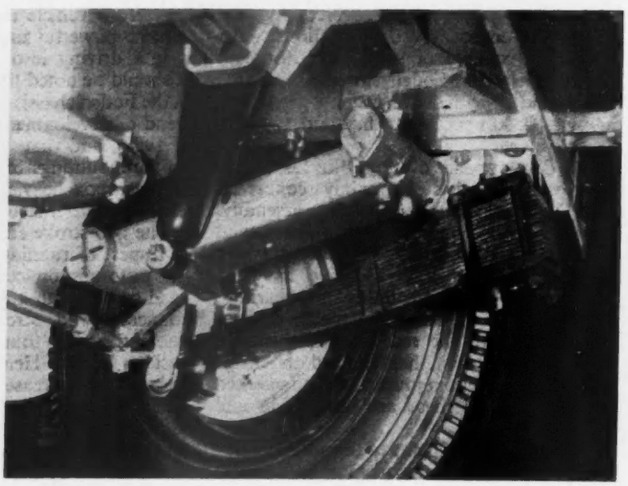


Fig. 6—The Trojan front suspension uses trailing arms swinging between plain and threaded bushes. The moments due to weight and braking forces are taken by a quarter-elliptic leaf spring. A track rod joins the steering arms of each hub, passing below the engine

well as extra oil to the combustion space has maintained the combustion efficiency.

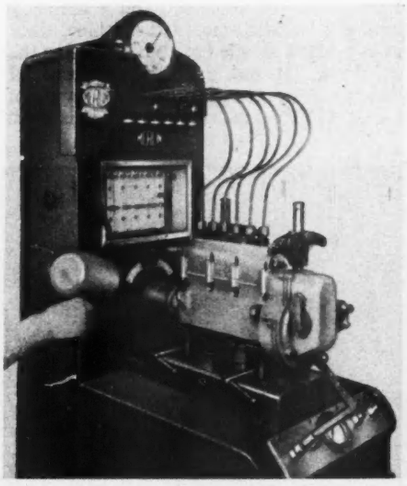
While the advantages of supercharging, particularly with an exhaust turbine, are now fairly well known, an exhibit by the Birmingham Small Arms Company, Ltd., drew attention to its advantages when an engine spends much of its time away from full rack, as is the case for vehicle applications. This was derived from results on two Daimler engines, an 8·6 litre with a B.S.A. turbocharger and a 10·6 litre without (see page 296, August 30, 1957). These engines had the same full rack

A water-cooled Eberspacher blower on the horizontal railcar version of the Leyland "E.N.900" engine: notice that the large manifold of the normally-aspirated engine is retained, with a short, sharply divergent, transition piece

steady-state outputs and only a small difference in full rack specific consumption, but, as the chart reproduced here shows, at reduced power the lesser friction losses of the smaller engine cause there to be a difference of about 25 per cent in the fuel consumptions, even though the turbo-compressor will be merely windmilling.

The dependence of the aerodynamic compressor on a high flow rate is one of the unattractive features of the turbocharger, since it means that the turbocharger does little or nothing to ease the problems of the transmission designer. The prospect of improving the performance at low rather than at high speeds, and at the same time of relieving the severe demand for extreme turbine loadings in order to cut down rotating inertia and delay in responding to the accelerator, was held forth by Rotol, Ltd. An animated diagram explained the functioning of the AiResearch pressure-ratio-controlled turbine by-pass system, which is to be manufactured in this country for use with blowers built by Rotol. It consists of a simple plug valve upstream of the turbine which, when open, allows exhaust to by-pass the turbine and pass direct to the exhaust pipe ; a silencer will presumably be necessary. The valve is either open or shut, and it is moved by pressure oil tapped from the engine lubrication system. (It may be recalled that this is a plain-bearing supercharger with continuous lubrication.) The valve opens at the command of a pressure ratio sensor mounted on the compressor. With this additional control, the supercharger can be matched to the engine at whatever speed it is desired to attain peak torque without any restriction on minimum turbocharger size to avoid over-speeding at full power. The automatic by-pass also protects the compressor against surge, but, clearly, not the turbine against over-temperature ; however, the reduced size of turbo-compressor that can be used results in over-temperature (and smoke emission) lasting much less long. This system is already fully developed for use with AiResearch blowers on Caterpillar engines.

It has to be recorded, however, that pressure-charging is the method of power increase least in favour with the vehicle manufacturers. Leyland and A.C.V., for instance, use turbo-charging only to attain powers higher than encompassed by their normally aspirated engines. The Leyland-Albion "900" engine was seen, in horizontal form, direct coupled to a Self-Changing Gears transmission, with a water-cooled Simms-Eberspacher blower giving 275 h.p. at 1800 r.p.m. The new A.E.C. 6⅛in by 6⅛in "A.1100" 17·9 litre engine, which is similar to the existing small wet-liner A.E.C. units (9·6 and 11·3 litre models have now been introduced, running up to 1800 r.p.m., or 2000 r.p.m. when a crankshaft damper is fitted) but has separate heads for each cylinder with four valves in each, gives the same power at its governed maximum of 1900 r.p.m., but it in its turn can be turbo-charged to yield 360 h.p. This large engine has a peak brake mean effective pressure of 124 lb per square inch at 1250 r.p.m. naturally aspirated and 163 lb per square inch supercharged ; the engine is not supercharged as highly as these figures suggest, the density ratio being 1¼ at 1400 r.p.m. and 1·4 at 1900 r.p.m.—the explanation of this is that the limit on the output of the unblown engine is smoke at high r.p.m., a limitation particularly easily raised by the turbocharger. The limit to the blown rating is set by the turbine inlet temperature, which reaches 660 deg. Cent. at 1400 r.p.m. for a pressure ratio of 1·5. The consumption is 0·375 lb per h.p. hour at the best point on the automotive rating ; it improves to 0·362 lb per h.p. hour at between 115–130 brake mean effective pressure and 1000–1200 r.p.m., which is equalled by the normally aspirated engine on its automotive maximum.

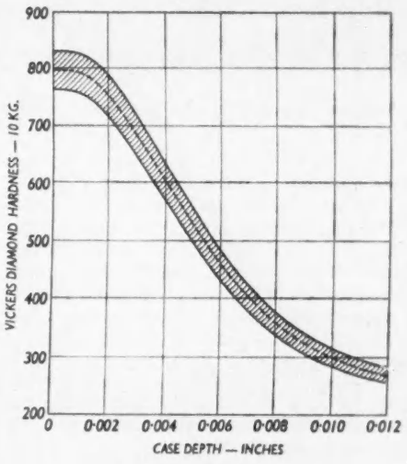


Phasing of a camshaft pump at operating speed

Both engines have the cylinders protected from cavitation by a flame-sprayed layer of alumina 0·005in thick ; this has no more effect on heat transfer than the normal rust.

However, as these high peak-torque speeds suggest, these engines are probably adapted to the rail traction applications for which they were offered by British United Traction, Ltd. One example of a road vehicle with a supercharged engine was the new Thornycroft "Antar" designed for use on the oilfields as a truck, whereas the "Mighty Antar" is a tractor ; both vehicles use the same axles and final drive, but instead of the 18 litre twin-o.h.c. V.8 "Meteorite" engine the new vehicle has the six-cylinder push-rod 11·33 litre K.R.N.6/S of 200 h.p. that was described on page 858, December 14, 1956. The in-line engine, like the two-bank unit, is placed in a bonnet in front of the cab, whereas the "Big Ben," in which it is also used, is available with forward control.

The main gearbox of the "Antar" also is common to the smaller vehicle, and by

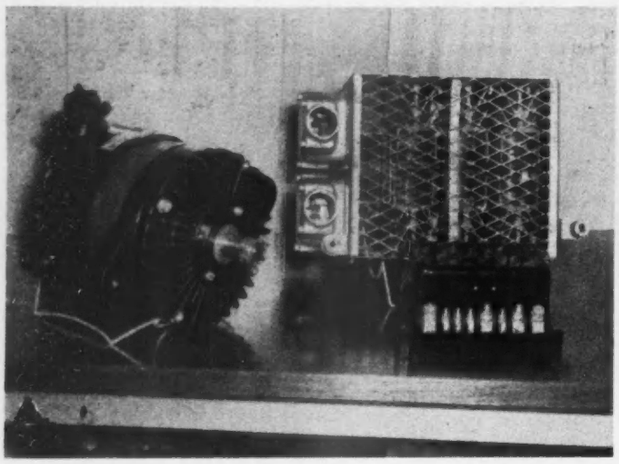


Surface hardness of "Hi-Ten"

using the transfer box of the new model front wheel drive can now be offered on the "Big Ben."

Equipment and Accessories

Dealing first with engine equipment, a new addition to the Merlin injection pump test bench was to be seen. This took the form of "Electroscopic" phasing, seen in progress in our illustration. On a test bench equipped for this process the delivery lines to the pump are not connected directly to the nozzles but to a set of adapters each of which communicates, past a screw-down valve, with a common duct. To this duct there is connected a single injector set to open at a low pressure—100 atmospheres—and provided with electrical contacts that detect needle lift. To these contacts is slaved a stroboscopic flash, made by E.M.I., which is used to illuminate a disc on the pump drive calibrated with the timing intervals for five-, six-, and eight-cylinder engines. To phase, the valve in No. 1 line is opened and the reference on the bench set opposite the origin of the calibrated disc ; when the valve for any other single line is opened, the phase of that element in relation to that chosen for No. 1 can be checked. The test can be carried out at all speeds, so that the functioning of an automatic timing adjustment can be checked. Since the light only flashes when fuel is being delivered, it provides a way of checking the governor idling cut-in speed and maximum run-out speed. One advantage of this system is that the phasing detector contacts are making and breaking only when a test is in progress, so that their life without attention is long. The stroboscopic light can be used independently for speed measurement or triggered



Alternator, air-cooled rectifier and control unit for public service vehicle electricity supply

A full set of four Lucas headlamps installed on a Guy goods vehicle

from an ignition pulse for timing a spark-ignition engine.

The Sheepbridge Stokes Company, Ltd., showed a new material for use as cylinder liners. This is a cast iron with the undissolved carbon in nodular or spheroidal form, a state usually associated with a significant degree of elongation and hence a greatly increased resistance to fracture.

" Hi-Ten " is the name given to spheroidal graphite iron, centrifugally cast, which has been nitrogen hardened after machining. The typical analysis would be :—

Total carbon	3·2 per cent
Silicon	2·2 per cent
Manganese	0·3 per cent
Nickel	1·8 per cent
Phosphorus	0·1 maximum
Chromium	0·1 maximum

The maximum strength is 35–45 tons per square inch and the elongation is 2 to 5 per cent ; the maximum hardness given by the nitrogen hardening is about 800 and the total depth of the nitrided case about 0·012in, as shown on the graph.

The nitrogen hardening of the bore surface increases wear resistance and cylinder life, whilst the nitrogen hardened outside, or water jacket, surface gives considerable added protection against cavitation erosion.

In this connection it may be observed that wet-liner engines with the water faces chrome-plated or ceramic coated were included in the exhibition.

Many public service vehicle operators are faced with the problem, on certain of their services at least, of maintaining the vehicle batteries in a satisfactory state of charge in spite of adverse running conditions and of long periods during which the vehicle may stand with the engine stopped but with the lighting load in use. This difficulty can be very considerably reduced, if not entirely eliminated, by the use of an a.c. charging system which will permit a high dynamo output to be obtained at low engine speeds. This could obviously be achieved with a d.c. generator, by driving the generator at an appropriately high drive ratio, but this in turn would mean correspondingly high dynamo speeds at maximum engine speed. In the case of the conventional d.c. generator, this wide speed range would impose severe commutation problems, but since the a.c. generator has no commutator, this difficulty obviously cannot arise with the a.c. charging system.

The alternator may therefore be designed to cover a wide speed range and to give its maximum output over the whole of this speed range. Such a machine will be lighter and simpler in construction than a d.c. machine with a comparable output and characteristics, and in addition will be fundamentally more reliable and less costly from the maintenance viewpoint ; there is, quite clearly, no need for the two-speed dynamo drive which is available on Rolls-Royce engines.

Since the a.c. machine is capable of generating the whole or a substantial part of its maximum output at engine idling speed, it follows that it is able to support the vehicle lamp load whenever the engine is running. Consequently, the demand on the battery is very much less and it is therefore possible to reduce the battery capacity and, therefore, its weight. The extent to which the battery capacity may be reduced will obviously depend upon local operating conditions, but under the most favourable conditions, the battery size may be reduced to that determined only by consideration of the engine starting requirements.

The C.A.V. alternator type AC8 is a totally-enclosed, three-phase machine of approximately 8in diameter, and is normally supplied as a swing-mounted machine, since this provides a simple means of adjusting the belt drive. It has a cutting-in speed of 800 r.p.m., attains its maximum output of 60A at 1250 r.p.m., and has a maximum permissible speed of 6000 r.p.m. for this application, although it can be quite safely driven at much higher speeds. The alternator is an imbricated-pole design, the rotor consisting of two six-fingered, cup-shaped portions mounted on the shaft so as to form a twelve-pole unit. The field coil is wound around the shaft and is enveloped by the twelve poles of the rotor, the excitation current being supplied through carbon bushes and sliprings which, since they are handling an average current of only 1A, should give long and trouble-free service.

The heavy current windings of the alternator are carried in the fixed stator portion, a feature which further emphasises the essentially simple nature of the AC8 alternator design. By this construction, the heat losses in the windings are more readily dissipated, resulting in a machine which is inherently cooler than its d.c. counterpart, but which, in any case, is not subject to the temperature rise limitations imposed by the commutator and its soldered connections in the d.c. generator.

The alternator is not affected by field polarity or by the direction of rotation of the rotor and it may therefore be used with either clockwise or anti-clockwise drives.

It is used in conjunction with a naturally cooled three-phase full-wave rectifier unit having either germanium or selenium

A dynamic brake tester in use : the two dials on the desk in the background show the instantaneous and maximum efforts on each tyre : notice the pedal force indicator on the driver's window

elements, the choice of rectifier being dependent upon such circumstances as the application, ambient temperature and space available. This unit, which is provided with resilient rubber mountings, includes a small auxiliary rectifier to provide the alternator field excitation, and is housed in a sheet metal container having expanded aluminium mesh at the top and bottom to allow a natural air flow for cooling purposes, as can be seen in our illustration.

The output of the alternator is controlled by means of a vibratory contact current-voltage regulator of conventional design. However, the normal type battery cut-out is not required, since the rectifier itself will prevent the battery from discharging through the alternator, when the latter is stationary.

Weights of Equipment

Alternator	53 lb
Rectifier unit (germanium)	16 lb
Rectifier unit (selenium)	27 lb
Control board	5 lb

Also shown by C.A.V., Ltd., was a new lighting system using four Lucas headlamps. This system is intended to overcome the problem of designing an optical system—reflector and lens—which by a mere change of light source will provide either a long-range or a meeting beam. It does so by using one lamp (or rather a pair of lamps) with two filaments, which provide either a meeting beam or a wide, deep spread of light over the road near to the vehicle ; the long range illumination is contributed entirely by a second pair of lamps with one filament only. The meeting and driving filaments in the first pair are 50W and 37½W, respectively, and those of the second pair 50W each ; thus, the consumption is 175W when driving and 100W when dipped. The lights are 5¾in in diameter, and they have three reference points embossed on the lens to allow them to be aligned by mechanical rather than optical equipment. The double-filament lights, which are on all the time, are mounted at the outside, or at the top if the lamps are mounted one above the other.

In view of the superficial resemblance of this equipment to the contemporary United States lighting sets, it is perhaps desirable to point out that these lamps are not one-piece glass-envelope light units with the conductors fused into the reflector. In order to allow mechanical aiming to be used, however, it is necessary for the bulb to be soldered in, and the bulb/reflector/lens assembly must be exchanged in the event of any failure.

There was shown by S. Smith and Sons (England), Ltd., a somewhat unusual set of electric instruments. It has long been accepted practice to use a bimetal strip instrument to present a quantity with a very long time constant, such as the cooling water temperature. This movement, however, has now been applied by Smiths to the other electric remote reading instruments such as fuel contents and oil pressure. It is claimed that the very heavy damping on the instrument means that the quickest glance obtains a correct reading, and that this is more important than the suppression of any short-period changes in the quantity sensed.

The movement is claimed to be more robust than that of the moving coil instrument. The bimetal strip, which is compensated for ambient temperature, carries a knife-edge, and a spring carries another; between the two is trapped the needle. The power dissipation is no larger than in a conventional instrument. The characteristics can be so shaped that identical movements are used in presenting pressure, temperature, and contents information.

The exhibition was also noteworthy for an unusually wide selection of rigid breaker tyres. The theory of these tyres has become widely known in the ten years since the Michelin " X " was introduced ; it may be desirable to recall that a flat breaker strip of high tensile strength is introduced into the tyre in order to resist the tendency of the internal pressure to cause the tread to arch. Since the strip has virtually no section modulus in the radial plane, it does not resist departure from a circular shape when viewed along the axis of rotation. Hence, the pressure over the ground contact patch is much nearer uniform than with a conventional tyre, and the peak pressures are far lower. This " track laying " characteristic has enabled vehicles with steel-cord tyres to pass through hitherto impenetrable reaches of the Sahara desert; hence, the " Sahara " tyres seen on the Scammell " Super Constructor." The uniform pressure also allows forces in the plane of the road surface to be developed with less relative movement ; hence, the long tread life. An example of this class of construction well known on the Continent, but not previously seen in this country, is the Pirelli " Cintura," of which a preproduction example was displayed. " Cintura " tyres made in Great Britain will have a rayon casing and a steel tread reinforcement, whereas the original design was entirely textile, so that at present full details of the tyre characteristics are not available. A third display was of U.S. Royal tyres, made by the North British Rubber Company, Ltd. It is perhaps worthy of note that British manufacturers also have experimented with tyres of similar construction.

Numerous devices are in existence for the measurement of the torque developed by vehicle brake systems. Many of these, however, measure the frictional force either with the wheel stationary or by stopping it over a short distance, so that the measurement may have as much relation to the " stick " condition as that of " slip." A different technique is employed in the dynamic brake tester displayed and demonstrated by Triangle Products, Ltd. On this equipment the wheels to be tested rest on rollers which are rotated by electric motors, one for each wheel, and the torque developed is measured by dynamometers with hydraulic signalling. The epicyclic reduction gears have a ratio sufficient to maintain motion against a locked wheel for a vehicle up to 10,000 lb weight. The rollers are surfaced with emery, a widely used standard surface for tyre testing. If the brakes are not applied sufficiently hard to lock the wheel, variation of torque with time will show up ovality of the drums and kindred effects.

The Montreal Power Conference

No. III—(*Concluded from page 523, October 3*)

A sectional meeting of the World Power Conference, the theme of which was " economic trends in the production, transportation and utilisation of fuel and energy," was held in Montreal from September 7 to 11. Our review of the conference concludes this week with an account of those sections of the conference dealing with the generation of power with conventional fuels, and of the papers and discussions falling under the general headings of " transportation " and " utilisation."

ALTHOUGH discussion of the generation of power in conventional thermal power stations was grouped under two headings, a distinction was not clearly drawn between them in the actual conference sessions, and it is more convenient here to group the two sections together. They were respectively Section B4 on system planning and Section B5 on design and operation, there being fifteen papers in Section B4, and six in Section B5.

For convenience the topics which attracted greatest interest in these two sections can be roughly classified as follows : (1) improvements in performance of thermal-electric generating plant ; (2) the use of low-grade fuels ; (3) heat-electric generation ; (4) combined gas and steam turbine cycles ; and (5) gas turbines for peak loads. All of these topics hinge on the common desire to reduce the cost of heat and power ; one other approach to this problem received favourable comment, namely, the work of the fuel efficiency service in Great Britain.

Large Turbo-Generating Sets

Pride of place in the discussion on turbo-generating sets was commonly accorded to the paper recording nine months' experience in operating the world's first major supercritical set at Philo power station in Ohio, U.S.A. This set has been described in these columns (The Engineer, August 2–16, 1957). Despite initial " teething " troubles on some ancillary equipment—principally boiler feed pumps—the set has proved generally satisfactory. While the technical problems have been solved, however, there was a general feeling that such a set was not yet an economic proposition because of its high capital cost ; that was largely expected by those responsible for installing it, since the set was professedly experimental, and the full economies are now within reach in larger sets, making use of design data and experience accumulated at Philo. Such large sets would, in the opinions of most of the speakers, have made a contribution to more economical power generation before many years elapsed. In fact, one speaker, from the U.S.A., asserted that by 1968 supercritical conditions together with fully automatic operation of steam power stations would be common practice ; he considered that in the next ten years some 150,000MW of new plant would have to be installed in the U.S.

Standardisation for these large machines was also discussed, and extension of the U.S. system of preferred standards to cover higher pressures and temperatures, and from the 150MW size now standardised to a 200MW standard, was suggested. There was no unanimity of view on the subject, however.

The general position to-day in the development of large steam turbo-generators was succinctly reviewed by the general reporter for Section B4, Mr. R. E. Tweeddale, whose remarks are abstracted hereunder.

In the past thirty years or so the heat consumption per kilowatt-hour attainable in large stations has been nearly halved, mostly

through advances in metallurgy and improvements in the turbine heat cycle. Formerly boiler efficiencies of over 85 per cent were considered non-economic. Now 88 to 90 per cent efficiencies are used. The better economies now made in the turbine cycle are mainly due to the adoption of the following :

(*a*) High temperatures and pressure of steam.

(*b*) Turbines of very large capacity.

(*c*) Heating of feed water by five to nine stages of extracted steam.

(*d*) Reheating in one or two stages.

Yet the thermal gain attainable by each of these means, and even by their combined use, has become sharply asymptotic. This is seen by considering the 325MW, 5000 lb per square inch, 1200 deg. Fah., double reheat Philadelphia (Eddystone) unit with its heat rate of 8000 B.Th.U. per net kWh. This rate is 20 per cent lower than a 10,000 B.Th.U. rate attainable with a simpler 100,000kW, 1450 lb per square inch, 1000 deg. Fah., non-reheat unit. The 20 per cent fuel saving made by the Philadelphia unit will be offset to some extent by its higher capital and maintenance costs : expensive alloys and elaborate designs are needed for the boiler, piping, valves and turbine to withstand the extreme steam conditions.

It is thus of interest to observe the size and other features of generating units being adopted in countries that have large thermal generating systems. In the larger part of the capacity installed in the last year or two in the United States, the steam conditions have been 1800 lb to 2000 lb per square inch, 1000 deg. Fah., with a single reheat to 1000 deg. Fah. Double reheating has been introduced with a few of the large turbines using the highest throttle pressures and temperatures ; for example the 125MW Philo unit of the American Gas and Electric Company now operating has throttle steam of 4500 lb per square inch, 1150 deg. Fah., and has a first reheat of 1050 deg. Fah., and a second of 1000 deg. Fah. The Eddystone unit* in Philadelphia will be operating soon and at the highest conditions of all—5000 lb per square inch, 1200 deg. Fah., with double reheat, both stages 1050 deg. Fah. A thorough analysis has been made recently by a large representative midwest United States utility whose generation is all in thermal stations. The analysis examines all the present and prospective economic and technical factors that would determine the most profitable size and features of the generating units to be added to this utility's system. The following observations are made on controlling economies :

(1) In their recent unit (325MW) a saving of 0·1 mill per kWh will mean an annual saving of 240,000 dollars, equivalent to carrying charges on an investment of 1,900,000 dollars. In 1983, the 0·1 mill saving would mean 1,000,000 dollars annually equivalent to carrying charges on 8,480,000 dollars.

(2) The time value of money has an important bearing on thermal economy and obviously to the greatest extent on the savings made in earlier years of operation.

(3) Projecting past trends, the analysis contemplates the following surprising inflations in costs during the next twenty-five years :—

	1958	1983
Fuel, cents per million B.Th.U. ...	31	65
Construction, per kilowatt, dollars	150	510
Labour, per kilowatt, dollars ...	2·84	11·40

The analysis arrived at the following conclusions for the Detroit system :—

(*a*) Size and type of units : that 340MW is to-day's economic size, and that present trends indicate above the 350MW unit size the reduction in installed cost per kilowatt will diminish considerably.

That, in general, with vacuums better than 1·5in Hg. absolute at the turbine exhaust flange, cross-compound units with the large multiple exhausts of 1800 r.p.m. low-pressure turbines would give better overall economy, even although the investment cost is more than for single shaft 3600 r.p.m. units.

(*b*) Throttle steam : that 2400 lb per square inch, 1050 deg. Fah. is the economic condition. That supercritical pressures with their high temperatures would not be an economic venture even with the thermal gain of 2 to 4 per cent indicated : serious developmental problems of metallurgy, pipe flexibility and operation would be involved.

(*c*) Reheat : that 1000 deg. Fah. was more desirable than 1050 deg. Fah. because the problems of metallurgy and maintenance increased by the extra 50 deg. Fah. would offset the thermal gain.

The technical advances used elsewhere for thermal economy are practiced extensively in the U.S.S.R.; large turbine generators and boilers, high pressures and temperatures of steam. Since, as has been said, the extra economy attainable anywhere by these means is asymptotic, the Russian engineers adopt on a large scale the economy of supplying heat as well as power from their stations. Thereby electric energy can be obtained for about 4500 B.Th.U. per kWh. By this method, in 1956, more than 3,000,000 tons of coal were saved.

Soviet works in 1956 manufactured and installed three 150MW single-shaft condensing turbines using 2500 lb per square inch, 1000 deg. Fah. steam. Boilers made for pressures up to 1500 lb per square inch are usually of a drum type and of capacities up to 500,000 lb per hour. For higher pressures up to 3000 lb per square inch, either drum type or once-through boilers are used. For critical or supercritical steam conditions, the once-through type is employed. An experimental once-through boiler for 4400 lb per square inch, 1100 deg. Fah. has been operated with conspicuous success for several years.

Turbines of 200MW are being made and for the next five years 300MW will be widely employed with 3000 r.p.m. single-shaft machines. When 600MW units are adopted it is planned to have them built as two-shaft machines.

Conditions peculiar to Great Britain dictate its special practices. The country is compact so transmission costs are not high. Each station is designed for system economy rather than for local needs. A 275kV super grid overlying an older 132kV grid connects the stations. The coal allocated to power stations is of only a 10,650 B.Th.U. per pound grade. The location of stations is interesting. Although the coast is never distant, many large units are in the interior near the mines. For those units cooling towers are used, there being few rivers large enough for condensing purposes. This arrangement, although entailing poorer vacuums, gives a better overall system economy than would the location of these units on the coast.

The national power system will soon be growing at an annual rate of 2000MW. The new coal and oil-fired stations planned up to 1962 include the following units :—Sixteen 100MW, thirty-nine 120MW, fourteen 200MW, and four 275MW. The 275MW units are tandem-compound using 2350 lb per square inch, 1050 deg. Fah., steam reheated to 1050 deg. Fah. Transport limitations set the maximum alternator size at 275MW. The next step planned is for a 550MW, cross-compound unit using duplicate 275MW alternators [1963 programme].

Low-Grade Fuels

Discussion under this heading was closely related to Section B1, on coal, which we reviewed last week, but here, of course, the emphasis was on utilisation in the power station. Those countries from which authors reported progress in the use of low-grade fuels in power stations were principally Russia, Belgium and Yugoslavia, though, of course, the use of low-grade fuels in British power stations received some attention and has already been mentioned here.

Surprisingly good results were reported from Russia in the use of special equipment —furnaces, boilers, burners and mills—for burning unusual and low-grade fuels. Thirty large power stations burned anthracite dust and over 40 per cent of the power generated in Russia was from combustion of lignites, peat and bituminous shales. Some of these fuels had a water content of 55 per cent, and an ash content from the dry product up to 60 per cent.

About 20 per cent of the power was produced by anthracite smalls. According to Russian contributors, the firing of such anthracite presented considerable difficulties due to its low content of volatile matter, low calorific value and consequently high ignition temperature of the air-fuel mixture. It was practically impossible to fire dust anthracite in the water wall furnaces of modern boiler plants without partly covering the water walls by heat-insulating structures. It had been usual practice to partly cover the furnace walls and the upper part of the dry bottom beneath the burners. Slag was removed in a solid state. However, such a practice made it difficult to avoid slagging of the furnace walls and especially of the dry bottom during fuel combustion. In recent years furnaces designed for removal of slag in a molten state and equipped with combined sloping-horizontal bottom had been introduced.

Performance results obtained by the use of this type of furnace indicated that the formation of molten slag during combustion was essential for steady and economical firing of pulverised anthracite. The removal of molten slag in modern dust-anthracite fired boiler plants considerably improved, under adequate conditions of firing, the furnace efficiency by reducing the losses due to incomplete combustion of fuel from 5–7 to 2–3 per cent. The solution of the problem of adequate dust anthracite firing had not been limited to the design of the furnaces mentioned. Soviet scientific research institutes were carrying out a detailed study of the firing of lean coal in cyclone furnaces. A boiler equipped with a cyclone furnace designed to fire pulverised anthracite was being installed at one of the U.S.S.R. power stations. The design efficiency of the boiler plant was 91·8 per cent.

Heat-Electric Generation

In considering the supply of heat as well as electricity in power station practice, a fundamental challenge to the engineer is made. To put the point directly, we again quote from Mr. Tweeddale's general report, when he listed four proposals for discussion. One of them was as follows : " Despite all the technical improvements in steam-electric generation, about three-quarters of the heat in the fuel burned is lost to the condensers in the overall national generation in most countries. The perennial challenge still faces

* See THE ENGINEER, May 10 and 17, 1957.

the engineer and economist : can he not devise economic means of salvaging this enormous waste by more extensive use of exhaust and extracted steam for industrial processes and district heating ?" This " perennial challenge " did not attract very much discussion, and in fact the general reporter's suggestions of utilising exhaust steam for industrial processes and district heating seemed to be the only practical possibilities. And here again, district heating from power stations seemed to be practised extensively, principally in Eastern European countries, judging from the conference papers. There were papers, partly or wholly on this subject from Russia, Poland, and Czechoslovakia. The rather apathetic general attitude to the subject can be exemplified by quoting from Professor Mordell, the general reporter for Section B5, who pointed out that in the Arctic, almost universally diesel engines were to be found driving generators with no use being made of the abundant waste heat, both in the coolant and the exhaust, beyond heating the engine-room ; some of the electricity produced was used as heat, and oil was burned under a boiler to produce more heat.

In Russia, the development of district heating is considered one of the principal methods of improving the efficiency of steam power stations. The Russian paper reviewing power station practice and economy quoted 192×10^9kWh as the country's total output of electrical energy in 1956 ; 163×10^9kWh was generated by all thermal stations, and the total generated in " electric utility steam stations " was 114×10^9kWh. The corresponding heat output—from steam or hot water—from these " utility " stations was $76{\cdot}4 \times 10^6$ M.kcal. " The capacity and power generation of district heat supply turbines for the year 1956 amounted to about 30 per cent of the capacity and power generation of steam power stations ; the share of power generation based on heat production was 8·7 per cent of the power generated by steam power stations." Russian plans for development of heat-electric generation were stated thus : " Further large-scale development of district heating will be accomplished by the construction of several large-capacity central heating and power stations operating at steam pressures and temperatures ranging from 90–130 ata and from 535 deg. to 565 deg. Cent. Some of these stations will be built at industrial sites and some of them will be located outside towns and will be used especially for heat supply. These central heating and power stations will be equipped with district heat supply turbines having a capacity of 50MW in a single unit and later will be equipped with 100MW turbines. Within the next few years district heat supply networks having a total length of 500km will be built in many towns."

The Polish author pointed out, however, in his review of the sphere of application of " steam extraction condensing turbines " that in some cases a loss of fuel, as compared with entirely separate supplies of heat and electricity, was possible, if the electrical system was of high efficiency.

Figures were also given for a public utility in New York where sales of electricity, gas and steam brought in respectively 79·9, 14·7 and 4·8 per cent of revenue. Because of the relative unimportance of the steam sales, and also because of high fixed charges and low annual load factors, the supply of steam or hot water for district heating was not extensively practised. By contrast the operation of a power station in conjunction with an industrial plant—particularly an oil refinery or a pulp and paper plant, had proved very attractive. A new factor which was remarked upon in the discussion, however, was that a greater rate of load growth had been experienced in the summer than in the winter, because of air conditioning requirements, so the annual peak had shifted from winter to summer. Thus when a steam supply had been available it had proved more economical to utilise it instead of an electric drive for air conditioning.

Combined Gas and Steam Turbine Cycles

By combining the gas turbine with the steam turbine, economies in fuel consumption of as much as 10 per cent per kilowatt-hour generated are possible in some cases, as compared with a high-pressure steam turbine alone. Various differing arrangements are possible in forming the combination, and in our report of the Vienna meetings of the World Power Conference (The Engineer, June 29, 1956) attention was drawn to some of the work then in progress on these combined cycles. Three papers on this topic were presented at the Montreal meeting ; one from Professor Melan, of Vienna, reviewed the two-cycle process in which the hot waste gases from a gas turbine are utilised in a boiler, which may have a supplementary firing system ; the second, from Kral, of Czechoslovakia, described recent work in that country, and is reproduced in abstract on pages 570–572 of this issue ; and the third, from two French authors, dealt specifically with the case where the gas turbine cycle included free-piston " gasifiers." This latter paper was also relevant to the matters discussed in the last section above, for the authors considered that a principal application was in the simultaneous production of electricity and process steam, and the combined cycle with free-piston gasifiers, they asserted, was capable of developing twice as much power for a given quantity of process steam as a steam plant with a back-pressure turbine, and, furthermore, largely independent control of power and steam production would be achieved together with overall efficiencies from 85 to 88 per cent.

The advantages of the combined gas turbine steam cycle were listed as (1) increase of thermal capacity, (2) improvement of overall efficiency, and (3) much greater flexibility of operation and lower fuel consumption at part loads. For example, the same total fuel supplied independently to a 115MW capability steam turbine and a 43MW capability gas turbine, would produce a total capability of 172MW if supplied to the same units in a combined cycle, a gain of 13MW. Again, a steam unit with an efficiency of 38·7 per cent combined with free-piston gasifiers in a gas turbine cycle of 34 per cent net efficiency gave an overall efficiency of 43 per cent.

Various ways in which the gas-steam cycle could be utilised were (*a*) pressurised boiler before the gas turbine ; (*b*) a boiler at atmospheric pressure after the gas turbine ; (*c*) and a superheater for the steam cycle installed before the gas turbine. A pressurised boiler furnace before the gas turbine resulted in a reduction in boiler size, an increase in overall efficiency, with the disadvantage that no solid fuel could be used because of erosion damage to the turbine blading. A boiler furnace at atmospheric pressure after the gas turbine had the advantage that any fuel, even pulverised fuel, could be used. There was, however, an increase in boiler size with an overall lower boiler efficiency. With a superheater for the steam cycle installed before the gas turbine, the advantage was a reduction in superheater size and in losses in the intermediate pressure steam piping. There was also an improvement in overall efficiency.

Gas Turbines for Peak Loads

Attention was also directed in the discussion of Section B4 to the advantages, such as low capital cost and ease of starting, offered by gas turbines for peak load duty. In fact, a Canadian project for a 100MW gas turbine peak load power station was the subject of a paper in the hydro-electric " system planning " section, and was referred to in Part I of this article. Three papers on gas turbines for peak loads were given in Section B4. One of them, from France, described five peak-load, gas turbine sets, each of about 6MW output, in Electricité de France's programme, and gave results of tests and operating experience for those of them already running. Swiss gas turbine sets being built for Canada—eleven of them —and one such set already in operation were discussed in another paper ; here, also, a graphical analysis relating capital cost, operating cost and annual hours of operation of power generation projects, was given. The capital cost per kilowatt and the operating cost per kilowatt-hour were ordinates and abscissæ respectively, thus giving points on the graph corresponding to the stations or generating sets under consideration. To compare the economy of two such stations, a straight line was drawn on the graph connecting them, and the slope of this line corresponded to the load factor, or the number of operating hours per year, giving equal power cost for the two projects.

Finally, two Swedish authors gave an account of a 40MW gas turbine set now under construction at Vastervik, in Sweden, for peak loads, this being the second example of a predominantly hydro-electric network meeting peaks in this way. In their opinion, an increase in size of gas turbine generating sets gave such a favourable economic return that large condensing sets could no longer be considered for peak load duty. The Vastervik set is situated at the end of a transmission line, and its use as a synchronous condenser will save about 1,000,000 Swedish crowns by postponing transmission line construction.

The effect of various sized changes in heat exchangers and intercoolers were discussed in this paper, the general conclusion being reached that intercooling increased the specific output and was the most effective single step to take in turbines of this size and application. Basically, the Stal 40MW turbine consisted of a high temperature turbine driving a high-pressure compressor, the intermediate pressure turbine driving a low-pressure compressor, and a dual-flow, low-pressure turbine driving the alternator. The turbine utilised heavy fuel, employed a gas inlet temperature of 700 deg. Cent. (1292 deg. Fah.), and a two-section intercooler. Treatment for heavy oil involved a certain amount of trouble, and was limited to electrically heating the fuel oil by continuous circulation and by keeping it at a temperature of 50 deg. Cent. (122 deg. Fah.). The unit required only 35 per cent of the cooling water of the equivalent steam units. It was expected that the completed plant would cost 82.50 dollars per kilowatt, of which 62 per cent was for the gas turbine, 17 per cent for the building, 9 per cent for the electrical equipment, 6 per cent for the circulating water plant and, lastly, 6 per cent for miscellaneous equipment.

Fuel Efficiency

Economies which can be made by studying the consumption of heat and power in industry were reviewed by W. A. McFarlane, of the National Industrial Fuel Efficiency Service of this country. The Service's work attracted attention at the conference, as a

worth while and rational approach to fuel economy. Mr. McFarlane reviewed the fuel industries themselves, and the general economic position they have achieved to-day, and went on to a more detailed appraisal of fuel surveys in various industrial groups. Results of such surveys showed that an average saving of 18·4 per cent of total fuel consumption was possible without major capital expenditure or reconstruction. We reproduce in the next two paragraphs the concluding summing up given by Mr. McFarlane in his paper.

Estimates of the capital expenditure required to save fuel in general industry may be summarised as follows :—

	Coal savings tons per annum	Total capital cost £	Capital cost £ per annual ton saved	Pay-off time years
Lancashire boiler tests	114,000	430,000	3·8	<1
Heat and power surveys	100,500	1,026,000	10·2	<3
Government loan Schemes	78,063	1,022,636	13·1	<3

It is thus apparent that there is considerable scope for improvement in the efficiency with which fuel is used in British industry, at a cost which is fully justifiable by the change in economic conditions. The potential for saving is estimated at 7,000,000 to 10,000,000 tons per annum, which would contribute substantially to reducing the country's energy gap. Fuel efficiency's contribution to this national problem has two outstanding advantages. First, it can be made at low capital cost ; second, it can be made quickly. The time required for the supply and installation of new equipment is short in comparison with that involved in the large works providing new sources of energy, a colliery or a nuclear power plant, for example.

Against this is the difficulty that, if savings running into millions of tons per annum are to be achieved, action is required of thousands of industrial firms. Each of these must convince itself of what is practicable in its particular circumstances and find whatever capital is required. There are, of course, many modern factories with fuel-using equipment which is the last word in design and which is maintained at a high standard of operational efficiency. The main problem lies in the older factories where the boilers and furnaces, which are robust pieces of equipment with long lives, reflect the economy of the time of their purchase, perhaps twenty five or even fifty years ago. Fortunately, there is evidence that the British industrialist is prepared to face this problem of modernisation, as in the immediate post-war years he met the need for re-equipment on his production line.

Geothermal Power

Section C of the conference, entitled " Thermal Energy—Other Sources," attracted two papers. One was a comprehensive review of the exploitation of geothermal power by two British authors. The only large-scale application is at Lardarello, in Italy, where 300MW is generated, but the 150MW plant for Wairekei, in New Zealand, is at an advanced stage of manufacture, and adequate steam has been proved. The second paper reviewed the utilisation of solar energy in North America. In both cases economic appraisals were given.

" Transportation " and " Utilisation "

The remaining sections of the Montreal conference did not bear so directly on the engineering aspects of fuel and power, so we have reviewed them here only very briefly. The general heading " transportation " applied to the transport of fuels. This general topic of " transportation " was covered in three sections, respectively " electric transmission," " rail, water, &c," and " pipeline."

Although engineering considerations were prominent in Section D on electric transmission (ten papers were presented in this section) the ground covered bore some similarity to the matters recently reported in these columns at the time of the C.I.G.R.E. conference in Paris.† Long distance transmission was discussed in papers from the U.S.S.R., Finland, Canada and Brazil. The Brazilian paper pointed out that the largest load centre in that country, Sao Paulo, was 300km to 800km distant from those inexpensive hydro-electric sites not yet developed. Problems involved in building transmission lines over these distances were explored.

Economic considerations were paramount in the five papers under the heading of " rail, water, &c " of Section E. Although the bulk transport of fuels by land and water was the theme of this section, it was pointed out that there was no paper on the road transport of fuels. The importance of short-haul coal movements in the United Kingdom was, however, referred to in the discussion and it was stated that 20 per cent of the coal for power stations was moved by road. No paper considered the relationship between siting power stations and transport costs. There was a contribution from the U.S.A. which demonstrated a trend towards the increased movement of fuel by water carriers.

The four papers in Section F not only covered economic trends governing the movement of fuel by pipeline, but also dealt with some specific technical points, viz., a new non-corrosive construction for high-pressure pipes, described by an Indonesian author, and a review of underground storage and its role in the French gas industry.

The four sections which covered " utilisation "—respectively utilisation in industry and commerce (Section G), farms and residences (Section H), transport (Section I), and under the heading of financing and tariffs (Section J)—seemed to offer wider scope of subject matter than all the rest of the conference. Economic considerations were given first place in most of these papers. In Section G, for example, most of the papers referred to the cost of energy and its effect upon a particular industry or group of industries. Again, the discussion in Section I was noteworthy for appraisal of the economics of the differing systems of haulage and electrification in railway practice.

One topic of exceptional interest in Section G may perhaps be referred to by quoting from the general report by Dr. J. Davis. A Japanese paper, he noted, described the manner in which surplus water and off-peak hydro-electric power generating capacity could be converted into storable products such as calcium carbide so as to reduce Japan's dependency upon imported coal and oil. The electro-chemical industry had largely been developed in Japan as a result of surplus hydro-electric power, made available by operating a number of plants producing carbides on daily or seasonal off-peak capacity using water which could not be stored for base-load use. It had thus been possible to improve greatly the efficiency of use of the water power resources of that country. Similar conclusions were deemed to apply to other electric furnace industries, and to the electrolysis of hydrogen. " It is obvious that the carbide industry is an effective tool, not only to regulate power supply throughout the year, but also to adjust general peak loads, monthly, weekly, or even daily .... The pumped-storage power station, which is operated in various countries and is being projected for Japan, will be much more costly and less efficient power-wise than a hydrogen electrolysis plant of the same capacity." Consequent economies in thermal generation, and improvements in energy quality such as greater stability of voltage, current and frequency in the power systems were also mentioned.

† See The Engineer, June 13, 20, 27 and July 4, 11

Conclusion

The Montreal meeting saw the admission of three new member countries to the World Power Conference. They were Peru, the Federation of Rhodesia and Nyasaland, and Uganda. It was also announced that the sixth plenary conference, which is to be held in Melbourne in 1962, will have as its theme " The changing pattern of power."

As a final comment on the significance of power and energy in the world to-day we quote from the introductory remarks made by the chairman of the conference's session B2, Mr. Beebee of the U.S.A. Mr. Beebee asserted that the muscle power of one individual in his prime was equivalent to the power needed to illuminate a 40W bulb continuously. In terms of income, he went on, that was equivalent to 1 dollar a year, or, alternatively, one cigarette per day. Thus he evaluated the significance of power on production, and hence in the structure of to-day's society and its standard of living.

Bletchley Flyover

Work began on September 29, on the Bletchley flyover, a £1,500,000 schemes on the London Midland region of British Railways. When completed the flyover will enable freight and coal traffic passing to and from London and beyond to by-pass the congested approaches to Euston and avoid haulage over the heavily used London routes. British Railways points out that this will not only result in faster freight train services but will enable more passenger trains to be run—especially when the electrification of the London Midland main line is completed. It is estimated that some eighty trains a day will be carried by the flyover.

The work now begun is being carried out by L. Fairclough, Ltd., and is the first of the large contracts to be placed for this project. The structure is of concrete and the design is such that whilst the main flyover carried the Oxford–Cambridge branch over the main lines, there will be connection from the Euston–Carlisle main lime North of Bletchley near the existing Denbigh Hall Signalbox (where the A5 trunk road passes under the main lines), to the main flyover.

The three approaches to the flyover will consist of earth embankments, contained by retaining walls where there is insufficient width of land available for a natural embankment. On the Oxford side the flyover will be approached by a viaduct of five spans of 50ft–60ft, on the Cambridge side by a viaduct of seven spans of 40ft–50ft and from the North by two spans where the existing Cambridge branch is crossed. The main portion of the flyover will consist of seven spans of 56ft with two special spans over the existing Buckingham–Fenny Stratford main road. These spans will be 85ft and are bounded by two spans of 50ft 6in. This provision has been made for a future road widening scheme. *In situ* piles will support the piers which will carry precast prestressed concrete deck units. The total length of the viaduct is 1358ft.

On the Accuracy of the Ohmmeter

By R. BRAAE, M.Sc.(Eng.), Hons.B.Sc.

Though ostensibly a discussion of the ohmmeter and its accuracy, this article actually endeavours to present a more general picture of the application of the theory of errors to the analysis of measuring equipment. After giving the theory of the ohmmeter, all the sources of error in the instrument are tabulated and their relative importance estimated. Next, a series of experiments is described by means of which the theory is tested, and finally the test results are analysed and discussed.

IN view of the popularity of the ohmmeter it is surprising to find how little attention the theory of this useful instrument has received. A few textbooks mention it cursorily, but otherwise one seeks in vain for any information on the subject.

It is hoped, therefore, that this theoretical and experimental investigation will prove of interest to those readers who employ the ohmmeter in their daily work and enable them to use it with greater knowledge and confidence. But the purpose of the article does not end here. The author has endeavoured to lend this discussion of the accuracy of a particular instrument a wider perspective so as to show the electrical engineer how the theory of errors can give him a deeper understanding of the capabilities and limitations of his measuring equipment.

Theory of Ohmmeter

Essentially the series connected ohmmeter consists of a sensitive moving-coil instrument, a variable resistor and a source of EMF, all connected in series (see Fig. 1). Before use

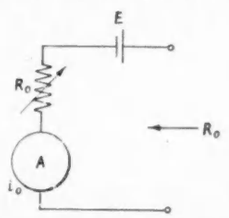


Fig. 1—Basic connection of ohmmeter

the instrument must be calibrated by short-circuiting its external terminals and adjusting the resistor until exactly full scale deflection (FSD) is obtained on the meter.

When an unknown resistance x is connected to the terminals, a deflection (less than FSD) is obtained from which x can be calculated by means of the expression

$$x = R_0 \cdot (i_0/i_x - 1) \quad . \quad . \quad . \quad (1)$$

where R_0 is the total resistance in the circuit (including the resistance of dry-cell and instrument), i_0 the meter current for FSD and i_x the current flowing through the meter. By means of this formula the scale of the ohmmeter is graduated directly in ohms, the value R_0 corresponding to the half-scale position of the pointer. The ohmmeter in effect compares the unknown resistance with its own equivalent output resistance.

To ensure that the instrument shall indicate the value of x correctly two conditions must be met:

(i) The FSD current i_0 must flow through the meter when the ohmmeter terminals are short-circuited, and

(ii) The output resistance R_0 of the instrument must be equal to the half-scale graduation.

These conditions can only be satisfied simultaneously for one particular value of the battery voltage E. In practice this difficulty is overcome by providing two variable resistors and connecting the instrument as shown in Fig. 2. With this connection the current through the meter itself when the external terminals are shorted is

$$i_0 = \frac{EQ}{\left[r+S+\frac{Q(P+R)}{Q+P+R}\right] \cdot (Q+P+R)} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and the equivalent output resistance is

$$R_0 = r+S+\frac{Q(P+R)}{Q+P+R} \quad . \quad . \quad (3)$$

The effect of this connection will be discussed below.

The Classical Theory of Errors

More and more electrical engineers are becoming aware of the necessity for knowing something about the theory of measurement and the theory of errors so as to be able to apply critical analysis to measurement problems. We shall only have space to mention the bare essentials of the theory of errors.

Theoretically an error is the difference between a measure of a quantity and its "true value." True values, however, while indispensable when developing mathematical models of macroscopic physical phenomena, are abstractions which we can never know. The best we can do is to estimate with a calculated risk of being wrong that they will lie between certain limits.

When a quantity is measured the result of the measurement will always appear in the form of a number. If a series of independent measurements are made of the same quantity, the measures will not all be identical, but will cluster about their mean value. According to the theory there are two types of error:

(i) Systematic errors, and

(ii) Random errors.

Systematic errors cause a one-sided shift of all the measures. They are particularly obnoxious in that they are extremely difficult to detect. They can often be eliminated by careful planning of the experiment.

Assuming that all systematic errors have been reduced to negligible proportions, the clustering of the results which still remains is due to random errors over which we have only limited control. Usually the clustering of the measures follows the "normal" law and their spread is indicated by means of the standard deviation. As the best estimate of the true value of a quantity the theory suggests the mean value of a number of measures.

If a quantity R is a function of two or more variables $x, y \ldots$, the measures of which are normally distributed, the standard deviation of the final result expressed in terms of the standard deviations of the individual measures is

$$s_R = \sqrt{\left[\frac{\partial R}{\partial x} \cdot s_x\right]^2 + \left[\frac{\partial R}{\partial y} \cdot s_y\right]^2 + \ldots} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and the values of R will also exhibit normal dispersion. As a result of this root-sum-squares (RSS) combination the largest contribution to the total uncertainty of the result will predominate. Hence, if we wish to improve the overall accuracy of a measurement, we must first concentrate our efforts on the worst offender.

Errors in the Ohmmeter

We shall now set ourselves the following problem: (i) To analyse theoretically the sources of error in the ohmmeter and (ii) to determine experimentally the errors of the instrument and endeavour to separate them into their individual components. In this connection it is important to remember that

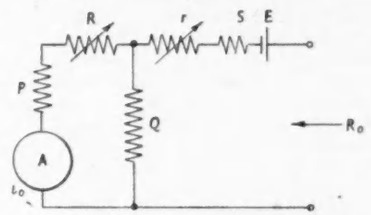


Fig. 2—Actual connection of ohmmeter

the deflection of the meter is a measure of the current flowing through it and that the indication in ohms which is read off the scale is, in fact, a derived quantity.

The total error in the reading is the result of a number of individual sources of error which we shall endeavour to classify as follows:

1. Errors in R_0 due to
(i) Calibration.
(ii) Errors in P, Q and S.
(iii) Errors in i_0.
(iv) Deviation of E from optimum value.
(v) Temperature effects.
2. Errors in i_0/i_x due to
(i) Incorrect adjustment of pointer on FSD mark.
(ii) Non-linearity of moving-coil meter.
3. Errors in the graduation of the ohm scale.
4. Reading errors.
5. Miscellaneous errors.
(i) Variation of battery voltage during measurement.
(ii) Variation of the switch contact resistance.
6. Personal bias and personal errors on the part of the observer.

Some of these errors are random in nature when we consider each individual ohmmeter, some can be classified under this heading only when we think of the whole population of ohmmeters, while others are inherently systematic due to the design and method of operation of the instrument.

In order to discuss the theory of the ohmmeter from the point of view of accuracy, it is necessary to consider each item in the above list separately so as to estimate its effect and how it varies with the meter deflection, or to devise experiments by means of which it may be separated from the other contributions.

Generally, once this analysis has been completed it is possible to decide whether it be feasible to improve the performance of the instrument.

Let us briefly deal with each source in turn.

Errors in R_0.—By re-arranging equations (2) and (3) we arrive at the following expressions

$$r = \frac{Q(E/i_0 - P - R)}{Q+P+R} - S \quad . \quad . \quad (5)$$

which shows the relationship between R and r that ensures FSD on the meter when the terminals are short-circuited, and

$$r = R_0 - S - \frac{Q(P+R)}{Q+P+R} \quad . \quad . \quad (6)$$

showing how R and r must vary to obtain a constant equivalent output resistance.

Fig. 3 gives the corresponding families of curves, two for each of the two ranges of the ohmmeter. The curves have been computed from the circuit constants of a well-known multimeter. Full lines refer to the Ω-scale and dotted lines to the Ω÷100 scale. It has been assumed that the dry cell has an equivalent resistance of 0·5Ω.

From Fig. 3 can be read all the required information concerning the calibration of the instrument. For a battery voltage of (say) 1·40V the correct operating point (for the Ω-scale) is the point of intersection between the constant i_0 curve for $E=1{\cdot}40$V and the $R_0=2000\Omega$ curve (point A). In practice, however, it is not possible to check the value of R_0 and the ohmmeter is therefore adjusted according to the FSD criterion only, which means that the operating point may lie anywhere along the section of curve BAC and R_0 fall anywhere within the range 1997–2002Ω. A maximum deviation from the correct value of 0·15 per cent is thus possible. In the Ω÷100 range the maximum deviation for the same battery voltage is 13·5 per cent.

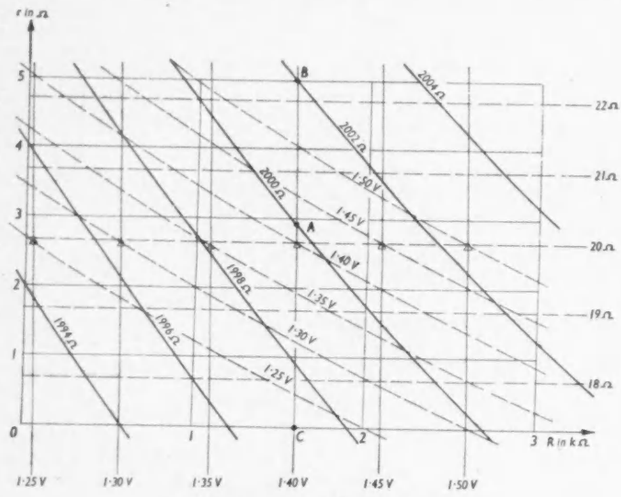


Fig. 3—Calibration chart for ohmmeter

It is clear that the above method of adjusting the ohmmeter can lead to serious systematic errors, especially in the low range. To counteract this tendency the manufacturers stipulate that the instrument must be calibrated on both ranges, although it may be the intention to use only one of them. This is possible with a little practice as R and r are common to both ranges. If this procedure is followed an operating point is reached at the intersection of the two constant i_0 curves corresponding to the given battery voltage. These points are indicated by small triangles in Fig. 3.

This technique leads to a remarkable improvement in the value of R_0 on the Ω÷100 scale. It suffers from the drawback, however, that the error which it introduces is systematic. On the Ω÷100 scale it is constant and equal to −0·5 per cent and on the Ω-scale it will vary between +0·15 and −0·5 per cent.

A deviation from its nominal value of the resistance P will displace the corresponding families of i_0 and R_0 curves an equal distance along the R-axis. A deviation of S will displace the same curves along the r-axis. According to the leaflet on the ohmmeter the resistors P, Q and S are "precision calibrated." We shall assume this to mean that they do not deviate more than 0·05 per cent from their nominal values. A rough quantitative check of Fig. 3 shows quite decisively that errors introduced in this way are quite negligible. Temperature effects, too, are unimportant.

The effect of errors in R_0 on the relative error in x can be computed from equation (1):

$$\left(\frac{\Delta x}{x}\right)_{R_0} = (\partial x/\partial R_0) \,.\, \Delta R_0/x = \Delta R_0/R_0 \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Thus the relative error in x introduced by a relative error in R_0 does not depend on the position of the pointer.

Errors in i_0/i_x.—It is inevitable that an error will occur when adjusting the pointer on the FSD mark. This error Δi_0 will cause a slight error in R_0, as can be seen from Fig. 3, but it will also influence the position of the pointer and thus falsify the measurement.

In the same way as before we can compute its effect on x.

$$\left(\frac{\Delta x}{x}\right)_{i_0} = \left(\frac{\partial x}{\partial i_0}\right) \,.\, \Delta i_0/x = \frac{1}{1-i_x/i_0} \,.\, \left(\frac{\Delta i_0}{i_0}\right) \quad . \quad . \quad . \quad . \quad . \quad (8)$$

In this case the relative error introduced in the reading x is a function of the deflection which tends to infinity when $i_x \to i_0$.

Non-linearity of the meter itself will introduce an error in the deflection i_x and this in turn will cause a relative error

$$\left(\frac{\Delta x}{x}\right)_{i_x} = \left(\frac{\partial x}{\partial i_x}\right) \,.\, \Delta i_x/x = -\frac{1}{\frac{i_x}{i_0}\left(1-\frac{i_x}{i_0}\right)} \,.\, \left(\frac{\Delta i_x}{i_0}\right) \quad . \quad . \quad . \quad . \quad . \quad (9)$$

in the reading x. Errors due to non-linearity will therefore have an effect that will increase rapidly with the distance of the pointer from its mid-scale position.

Errors in the Graduation of the Ohm Scale.—Assuming that errors in the graduation of the scale are independent of the position on the scale, the resultant relative error in x will vary with the deflection according to equation (9).

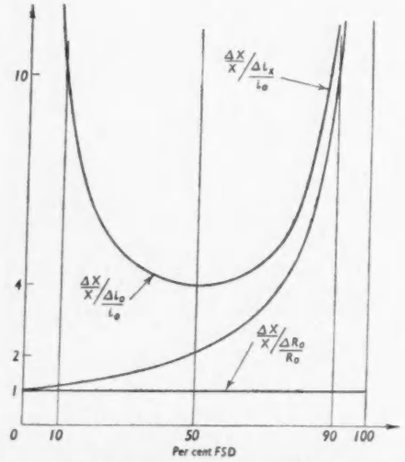


Fig. 4—Relative importance of partial errors as functions of meter deflection

Fig. 4 shows how the ratios of the relative error in x and the relative errors in R_0, i_0 and i_x vary with the position of the pointer. The three curves clearly indicate the relative importance of the various sources of error.

Reading Errors.—Obviously no mathematical theory can account for mistakes in reading the ohm scale or other faults in the operation of the instrument due to carelessness or lack of skill on the part of the observer. But even a skilled and attentive experimenter must estimate the last decimal point or two when reading the indication on the meter and in this way an unavoidable "reading error" is introduced. Fortunately, as can be shown by means of a simple test, the non-systematic components of errors of this type are normally distributed.

It seems probable that the absolute uncertainty with which the position of the pointer is estimated is constant throughout the range of the meter. Consequently, the relative error of the reading x will vary along the scale according to expression (9).

Miscellaneous Errors.—It was noticed during the tests that the contact resistance of the range switch varied erratically while the ohmmeter was being adjusted. The equivalent resistance and EMF of the dry cell also changed while measurements were being made.

Personal Bias.—Under this heading psychology enters into the discussion. I is an established fact that every observer has his "personal equation," a subconscious tendency to introduce one-sided errors into his readings.

Ignorance is an excellent weapon against personal bias. The experimenter should concentrate on the measurement that he happens to be doing without speculating as to how the figures that he is producing fit into the pattern predicted by his theories.

Experimental Work

To test the theory three sets of measurements were made. Each set consisted of six series of measurements and each series of ten repetitions of the "same" measurement of an unknown resistance.

Each measurement made with the ohmmeter was immediately repeated with a precision Wheatstone bridge. Seeing that the accuracy of the bridge was 0·05 per cent (an accuracy roughly fifty times better than the best accuracy claimed for the ohmmeter) we are justified in regarding these results as "true values."

The resistors used for the experiment were robust wire-wound variable resistors of the rheostat type with a short-time stability more than adequate to avoid any random variation of their values contaminating the results.

The three sets of measurements were as follows:

Set 1.—Measurement of x by direct reading of the ohm scale. The rheostat was set to the desired order of magnitude (say 10 per cent FSD), the ohmmeter calibrated according to the 2-scale FSD criterion, the reading made, the ohmmeter calibration rechecked and the "correct" value of the resistance measured on the bridge. This process was repeated at 50 and 90 per cent FSD whereupon the whole sequence was taken over again (10 times in all). While operating the bridge the observer concentrated on obtaining a definite balance without glancing at the position of the switches.

Set 2.—This set was taken simultaneously with Set 1 by reading the meter deflection on the linear scale of the instrument. So as to

avoid any bias, the calculation of x was not performed until the whole set of measurements had been completed.

Set 3.—By adjusting the rheostat the pointer of the ohmmeter was made to coincide with a certain graduation on the ohm-scale before the "true value" was determined. Because this type of adjustment is much more accurate than that of reading a random position of the pointer, we are justified in assuming the measures of Set 3 to be virtually free from reading errors.

In order to establish whether the erratic EMF and internal resistance of the dry cell was causing an increased systematic error or producing a wider scatter of the test results, Set 1 was repeated using as a source of EMF a lead-acid battery suitably shunted and tapped to make it equivalent to a 1·5V source of 2Ω internal resistance.

For each series of measurements (comprising ten measurements of the "same" resistance) the following figures were determined:

(i) The deviation (f) of the mean from the true value expressed in per cent of the true value. This figure is an estimate of the systematic component of the errors of the measurement.

(ii) The standard deviation (s) of the measures expressed in per cent of the mean value. This figure provides an indication of the degree of scatter of the results.

All these data are set out in Table I.

TABLE I—*Experimental Values of Systematic Errors and Standard Deviations*

Range	Source of EMF	Set		10 per cent FSD	50 per cent FSD	90 per cent FSD
Ω-scale	dry cell	1	f	−0·5	+1·1	−4·6
			s	0·69	0·29	0·89
		2	f	+0·9	+1·2	−0·7
			s	0·56	0·30	0·80
		3	f	+1·1	−0·7	+4·5
			s	0·20	0·22	1·0
	lead-acid cell	1	f	−0·6	+2·0	−2·4
			s	0·40	0·20	1·80
Ω÷100 scale	dry cell	1	f	−0·4	+1·8	−1·2
			s	0·47	0·25	0·90
		2	f	−1·1	+1·9	+2·6
			s	0·60	0·30	1·6
		3	f	+1·0	−1·7	−0·8
			s	0·32	0·16	0·90
	lead-acid cell	1	f	−0·2	+1·3	−2·4
			s	0·60	0·40	1·1
Mean value of s for Sets 1 and 2				0·55	0·29	1·18
Mean value of s for Set 3 ...				0·26	0·19	0·95

Analysis of Test Results

Random Errors.—When studying the random errors of the measures listed in Table I there are five points which immediately meet the eye.

1. The random errors as represented by the standard deviations s all exhibit a "dip" at mid-scale thus showing the effect of those errors which vary according to equation (9).

2. The prediction that the random errors would be larger for large deflections than for small deflections (see equation (8)) is clearly demonstrated.

3. A comparison between the results in Set 3 and those in Sets 1 and 2 shows that the reading error is not negligible.

4. By comparing Sets 1 and 2 it is apparent that there is nothing to be gained by reading the pointer position on the linear scale and then computing the value of the unknown resistance instead of reading x directly off the ohm scale. This indicates that the error of graduation of the ohm scale is insignificant and that the cramped scale is no more difficult to read than a linear scale.

5. Replacement of the dry cell by a more stable source of EMF does not improve the accuracy of the instrument.

Calculation of Random Reading Errors.—Because of the technique of observation employed, the measurements of Set 3 are assumed to be practically free from reading errors. We can therefore obtain an estimate of these errors from the expression

$$s_1^2 = s_2^2 + s_r^2 \quad . \quad . \quad . \quad . \quad . \quad (10)$$

where s_1, s_2 and s_r are respectively the mean standard deviation of Sets 1 and 2, the mean standard deviation of Set 3 and the standard deviation due to the uncertainty of reading the scale.

This approach yields the figures given in Table II.

TABLE II—*Calculation of Reading Errors*

Pointer, position	10 per cent FSD	50 per cent FSD	90 per cent FSD*
s_1 in per cent	0·55	0·29	1·18
s_2 in per cent	0·26	0·19	0·95
s_r in per cent	0·48	0·22	0·70

* In the case of Set 3 this figure is nominal. Ninety per cent FSD corresponds to 222Ω (2·22Ω) and since no scale mark was provided for this value the 200Ω (2Ω) mark was used instead. This accounts for the dissymmetry of the ratios.

According to the theory the ratios of the standard deviations s_r for the given pointer positions are 11·1 : 4 : 12·1, which prediction compares quite well with the actual figures, especially when we bear in mind that the uncertainty of an uncertainty is of the order of 25 per cent. The uncertainty with which the position of the pointer is estimated is a quarter of s_r at mid-scale and this amounts to about a twentieth of the smallest division on the linear scale of the meter.

Calculation of Random Calibration Errors.—We shall now assume that the residual random errors represented by s_2 are due mainly to the two sources R_0 and i_0.

Because their contributions to the relative errors in x are different functions of the meter deflection, we are able to resolve s_2 into two components: s_R due to random errors in R_0 and s_i due to random errors in the adjustment of the meter on its FSD mark (i_0). This procedure is analogous to the Epstein method of resolving iron losses into their hysteresis and eddy-current components.

As can be seen from equations (7) and (8) the relative weights of these sources at 10, 50 and 90 per cent FSD are respectively 1 : 1 : 1 for R_0 and 1·1 : 2 : 10 for i_0. Hence we arrive at the following three equations in the two unknown quantities s_R and s_i.

$$s_R^2 + (1 \cdot 1 s_i)^2 = 0 \cdot 26^2$$
$$s_R^2 + (2 s_i)^2 = 0 \cdot 19^2$$
$$s_R^2 + (10 s_i)^2 = 0 \cdot 95^2$$

As might be expected the equations are mildly contradictory. We are therefore compelled to obtain a reasonable solution by means of the method of least squares. This leads to

$s_R = 0 \cdot 17$ per cent ($\doteq 0 \cdot 2$ per cent) and
$s_i = 0 \cdot 09$ per cent ($\doteq 0 \cdot 1$ per cent).

Systematic Errors.—With regard to the systematic errors the picture is confused and the problem of analysis much more formidable. Systematic errors do not conform to any definite pattern and it would be fatuous to endeavour to draw too many conclusions from the available data.

Two facts, however, clearly emerge. First, the figures show a decided tendency to increase with the deflection of the meter. This would seem to point to the operation of adjusting the meter on the FSD mark as the principal culprit as far as the systematic errors are concerned. This supposition is borne out by the fact that the predicted constant systematic error of −0·5 per cent in the Ω÷100 range is nowhere in evidence and appears to have been completely swamped by other contributions.

Secondly, the systematic errors are generally large in comparison with the random errors.

To sum up the results in Table I we can compute the figure which is usually given as the "accuracy" of an instrument, namely, the limiting error which no measurement properly and carefully performed will ever exceed. The classical theory of errors allows for infinitely large random errors, but practical experience has shown that they will never be larger than approximately two and a half times the standard deviation s. Under the assumption, therefore, that the results set out in Table I are a representative sample of the performance to be expected from the ohmmeter, we ought to be safe in saying that no reading will deviate more than $|f_{max}| + 2\frac{1}{2}s_{max}$ from the correct value. The figures computed in this manner are given in Table III. They show the claims made by the makers to be quite conservative.

TABLE III—*Conventional Accuracy of Ohmmeter*

Position on scale	10 per cent FSD	50 per cent FSD	90 per cent FSD
"Accuracy"	2·8 per cent	2·8 per cent	9·1 per cent

Conclusion

In order to contribute something positive, an article like this ought (after analysing the experimental results in the light of the theoretical predictions) to suggest some means of improving the performance of the instrument under discussion.

Following the recommendations made in section 3 to attack the worst offender first, it would be advisable to try to improve the stability of the FSD adjustment. The small value of s_i indicates that the human element is not too much at fault in this case. There was, however, a distinct tendency for the FSD setting to creep while the instrument was in use. The dry cell does not appear to be responsible as evidenced by the comparatively large values of f and s in the series of measurements where a lead-acid battery was employed. The whole question warrants further analysis.

Limiting the variation of R and r would reduce the systematic error in R_0 on the Ω-range, but for one thing the effect of errors in R_0 is not as pronounced as that of other sources, and, secondly, such a procedure would require frequent change of dry cell which would inconvenience and annoy those users who are not particularly interested in accuracy.

To obtain good results with the ohmmeter the following rules should be adhered to: (i) Calibrate the instrument carefully on both ranges on the FSD mark, and (ii) only use the instrument in the range 15 to 80 per cent FSD.

All in all our investigation has shown up the ohmmeter for what it is: a compact easily operated instrument which properly handled will yield results that are quite accurate enough for most practical purposes.

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Metallurgical Topics

Electromagnetic Determination of the Effects of Shot-Peening

IT is well known that the fatigue strength of steels can be greatly increased by the use of various surface-hardening processes ; such as cold-rolling,* case-hardening,† nitriding‡ and shot-blasting.§ When using the last method, the increased fatigue resistance depends upon the effective depth of the plastically-deformed surface layer produced in this process. In certain limited cases, this can be determined by a micro-hardness survey of a transverse micro-section. Sometimes, an X-ray diffraction analysis of the depth of this layer by the letter *d* or the Greek delta. This depth is dependent upon what they call a "generalised parameter, *M*," representing the specific work of shot-peening, and determinable by a calculation involving such variables as shot speed, intensity, angle of impingement and peening time. The depth of compressed layer *d* is plotted against specific work of shot-peening *M*. Peening intensity is denoted by the symbol *V*, which is a measure of shot velocity in metres per second. Fatigue improvement is shown by plotting cycles to failure against shot velocity or intensity, stress values being omitted.

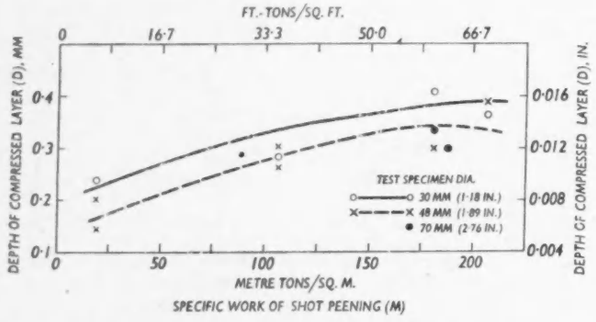


Fig. 1—Depths of compressed layer for three bar sizes of a Cr-Ni-Mo-V steel hardened and tempered to Rockwell C 45-48

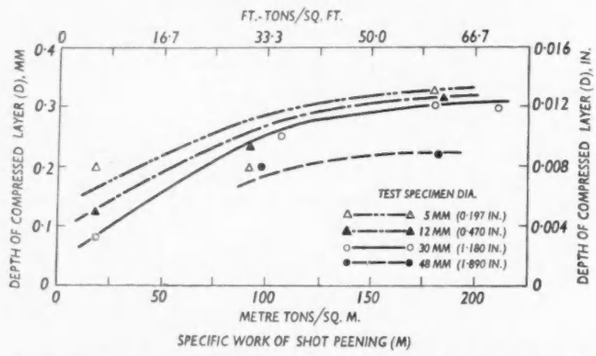


Fig. 2—Curves showing the depths of compressed layer for four bar sizes of a silicon steel hardened and tempered to Rockwell C 47-49

stressed material, or a measurement of the extent of deformation, may also be made. In a Russian paper by N. A. Petrov and M. Y. Shashin,‖ the depth of the strain-hardened layer of a magnetic material is measured electromagnetically by using an alternating current field at sonic frequency, measurement being obtained by determining the self-inductance of the coil in the transducer. This coil, in turn, is linked into one of the arms of a resistance bridge, which is balanced against a standard specimen. The unbalance produced by the object investigated is a characteristic of the strain hardening of its surface layer. The Russians represent the

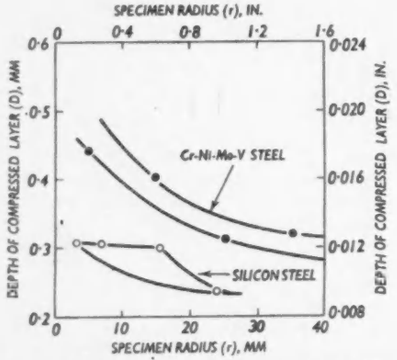


Fig. 3—Relation of specimen diameter to depth of compressed layer for Cr-Ni-Mo-V and silicon steel

The method of plotting depth of compressed layer is seen in Figs. 1 and 2, where the diameters of the specimens peened are shown. The shot size is not shown, but is presumably incorporated in the *M* value, the specific work of shot-peening. In both figures, a maximum depth of strain-hardened layer is reached at an *M* value of some 150 tons, the curves for both the Cr-Ni-Mo-V and silicon steels levelling off beyond this point. Further peening would thus not improve fatigue resistance.

It will be appreciated that it is possible to over-peen, giving an abraded surface of reduced fatigue resistance. To provide some measurable control, conventional peening practice requires a measurement of effective peening, as can be obtained by the use of the so-called "Almen strip," a steel strip, 0·0510in thick, hardened to Rockwell C 44-50. For test purposes, the strip is clamped in a holder and exposed to the shot stream. Compressive stresses build up on the exposed side of the strip ; so that, when it is removed from the holder, it assumes a curved shape. The extent of curvature is described as "arc height," and is measured in a special height gauge ; thus providing a simple means of duplicating a peening intensity that has already been established for a specific part.

Fig. 3 shows, for identical peening conditions, the effect of bar diameter on the depth of compressed layer. As diameter increases, depth of hardening decreases, the curves tending to level off with diameters of 2in and over. Fig. 4 shows the stress cycles for various diameters and shot velocities for a silicon steel of Rockwell C 46–48. By determining the depth of hardened layer with varying shot velocities in this manner, one can establish optimum peening conditions, and estimate fatigue life, without doing fatigue tests, and service tests confirm this claim.

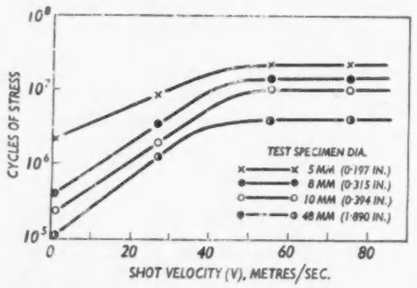


Fig. 4—Electromagnetic determination of optimum peening conditions for a silicon steel of given hardness —Rockwell C 46-48

Fatigue Under Fretting Conditions

FRETTING or chafing corrosion is a term used to describe the surface damage caused by slip of small magnitude between two closely-fitting surfaces intended to be fixed in relation to each other, but which are actually subject to minute alternating motion induced by vibration. When the parts are of steel, oxidation of the resulting debris gives rise to the cocoa-coloured iron oxide, an abrasive powder—increasing the initial surface damage—being thus produced. The wear is usually greater with increase in the amplitude of movement, the number of oscillations and the pressure between the surfaces. If, however, the load between the contact faces is so increased that all sliding motion is prevented, fretting corrosion cannot occur. The effect is thus not one of corrosion as generally understood. According to G. A. Tomlinson* and his collaborators, fretting can be produced by a relative motion of the order of 8×10^{-6}cm. Its effect is to reduce fatigue strength greatly, as seen in the testing of cylindrical test pieces, which break by the development of fatigue cracks from fretted areas in the clamps, the endurance limit being much lower than that of the normal material. This has been shown by H. W. Gillett and E. L. Mack,† and by A. Thum and F. Wunderlich,‡ respectively.

* H. Isemer, *Metallwirtschaft*, 1931, Vol. 10, page 714; A. Thum and H. Weigand, *Zeits. des Ver. deut. Ingenieure*, 1933, Vol. 77, page 1061 ; O. J. Horger, *Trans. Amer. Soc. Mech. Eng.*, 1935, Vol. 57, page A128 ; O. J. Horger and J. L. Maulbetsch, *Trans. Amer. Soc. Mech. Eng.*, 1936, Vol. 58, page A91 ; O Föppl, *Mitteilungen des Wöhler Instituts*, 1938, No. 3, page 55.

† H. Wiegand and R. Scheinost, *Archiv für das Eisenhüttenwesen*, March, 1939, page 445.

‡ H. Sutton, *Metal Treatment*, 1936, 2, Summer, page 89.

§ E. E. Weibel, *Trans. Amer. Soc. Mech. Eng.*, 1935, Vol. 57, page 501 ; J. H. Frye and G. L. Kehl, *Trans. Amer. Soc. for Metals*, 1938, Vol. 26, page 192.

‖ *Iron Age*, June 5, 1958, page 121.

* *Proc. Roy. Soc.*, 1927, Series A, Vol. 115, page 472 ; *Proc. Inst. Mech. Eng.*, 1939, Vol. 141, page 223.

† *Proc. Amer. Soc. Test. Mat.*, 1924, Vol. 24, page 476.

‡ *Mitt. Techn. Hochschule Darmstadt*, 1934, No. 5 ; *Zeits. des Ver. deut. Ingenieure*, 1933, Vol. 78, page 851 ; *Ibid.*, 1934, Vol. 79, page 823.

Fretting fatigue endurance values are of much the same order as those shown by test pieces sharply notched, and G. Sachs§ goes so far as to say: "If the relation between notch fatigue strength and chafing fatigue strength should be more definitely established, such fatigue tests on cylindrical specimens may also replace the fatigue testing

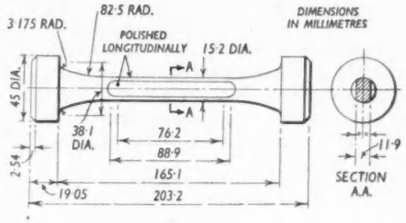


Fig. 1

of notched specimens which are difficult to produce uniformly."

Direct stress fatigue tests have recently been carried out by A. J. Fenner and J. E. Field‖ on L.65 aluminium alloy and mild steel, both without clamps and under various conditions of clamping, particularly to study the effect of fretting with a low amplitude of slip. The fatigue tests were made on the Avery-Schenk and Schenk-Erlinger 20-ton pulsating machines. Most of the test pieces were of the type shown in Fig. 1, having a section of 1·613 square centimetres, but, for certain tests it was more convenient to use a larger test piece, of 2·71 square centimetres

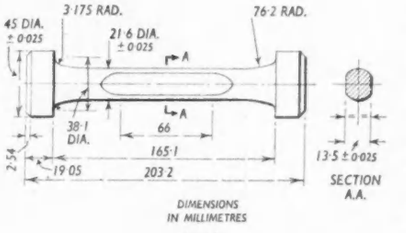


Fig. 2

section (Fig. 2). A satisfactory agreement was established between the normal fatigue values obtained by using the alternative types of test piece. The clamps used, in the form either of a ring or a bridge, were as shown in Fig. 3, the nominal pressure in both cases being 0·4 kg per square millimetre. The clamp of bridge type was formed of a rectangular block, with a narrow projecting zone at each extremity, by means of which the clamping pressure was applied. These clamps were of different sizes, for use with test pieces varying from 2mm to 35mm in length. The surfaces of the test pieces and of the pressure clamps were polished longitudinally to a finish of 2 or 3 micro-inches C.L.A., obtained with a 0000 emery paper, using a suitable lubricant. Immediately before the beginning of a test, they were cleaned with xylene.

In preliminary tests on L.65 aluminium alloy, made under a mean tensile load of 20 kg per square millimetre and with a given super-added limit of alternating load, the endurance was tested with clamps exerting a pressure varying between 0·015 kg and 12·5 kg per square millimetre. Under alternating loads of about ±10 kg to ±14 kg per square millimetre, the endurance did not seem to be greatly affected under the lowest pressure (0·015 kg per square millimetre), but was progressively reduced as the pressure extended to about 12·5 kg per square millimetre. In later fatigue tests on L.65 alloy, based on 20,000,000 cycles, made under a mean tensile load of 20 kg per square millimetre and a semi-range of alternating direct stress, the endurance limit of this alloy, ±13 kg per square millimetre in the absence of clamping, was reduced to a value as low as ±2·4 kg per square millimetre by fretting under clamps of the same material in contact with the test piece under a pressure of 0·4 kg per square millimetre. It should be noted that, in fatigue tests on L.65 alloy with a mean load of nil, i.e. under loads varying symmetrically about zero, the endurance limit for 20,000,000 cycles for test pieces not clamped was found to be about ±14·7 kg per square millimetre; i.e. some 12 per cent higher than with a mean load of 20 kg per square millimetre.

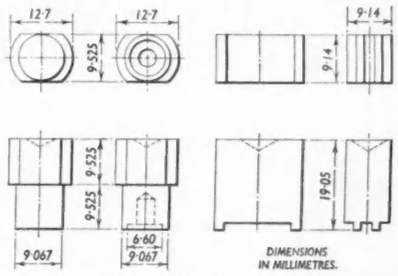


Fig. 3

The effect of amplitude of slip is shown in Fig. 4 for nominal slip values of 0·0025mm, 0·0038mm, 0·005mm, and 0·0063mm (1in, 1·5in, 2in and $2·5 \times 10^{-4}$in, respectively), using three test pieces for each value. The mean endurances for each group have been shown as a function of the applied load. It must be emphasised that the slip values are only nominal, for the relative oscillatory movement between the surfaces in contact consists partly of elastic and partly of plastic deformation. There is a definite relation between the fatigue resistance and the limits of slip, the resistance progressively decreasing as the slip increases from 0·0025 mm to 0·0075mm, but a further increase up to 0·023mm does not lead to any further reduction in fatigue resistance.

Interrupted tests, in which the clamps are removed after a variable number of cycles, appear to show that, after a period of about one-fifth of the normal service life in a clamped state, the fretting damage has extended into a region of the material situated beyond the effect of the clamps; so that a continued application of the load cycles causes failure at the same endurance, whether the clamps have been removed or not. If, however, the clamps are removed before this critical stage has been reached, the endurance is the same as that of the unclamped test piece, in spite of the fact that fretting has caused visible surface damage. The critical stage is reached at about one-fifth of the duration of the fretting, whether this itself is either 10^5 or 10^6 cycles.

The physical process of fretting corrosion consists in the repeated welding together of the asperities on the two surfaces, these joints being in turn broken, with the transfer of metal from one surface to the other, and the formation of metallic debris. The accumulation of oxide debris tends to separate the two surfaces, and wear proceeds by the abrasive attack of the oxide particles on the metal surfaces. This matter was investigated by making a pair of pressure clamps of bridge type from fragments of a broken abrasive wheel consisting of aloxite (aluminium oxide mixed with resin) of Grade P 500, these clamps being of the same shape as the aluminium alloy clamps which had been previously employed. The reduction in fatigue resistance by using these abrasive clamps was, however, very much less than that shown when using the similar clamps in aluminium alloy, although the surface wear and the amount of debris produced was very much greater. Although the damage was extensive, no important pit could be observed microscopically. It thus seems probable that the abrasive effect of metallic oxides has only a slight effect on the fatigue resistance under fretting conditions.

The foregoing conclusions refer substantially to the tests on the L.65 aluminium alloy. Preliminary tests on the mild steel (0·095 per cent carbon content) under clamping conditions similar to those used in the tests on the aluminium alloy have shown that mild steel is less affected by local fretting, typical endurance limits for 20,000,000 cycles being ±18·5 kg per square millimetre without clamping, and at least ±16 kg per square millimetre with pressure clamps of mild steel.

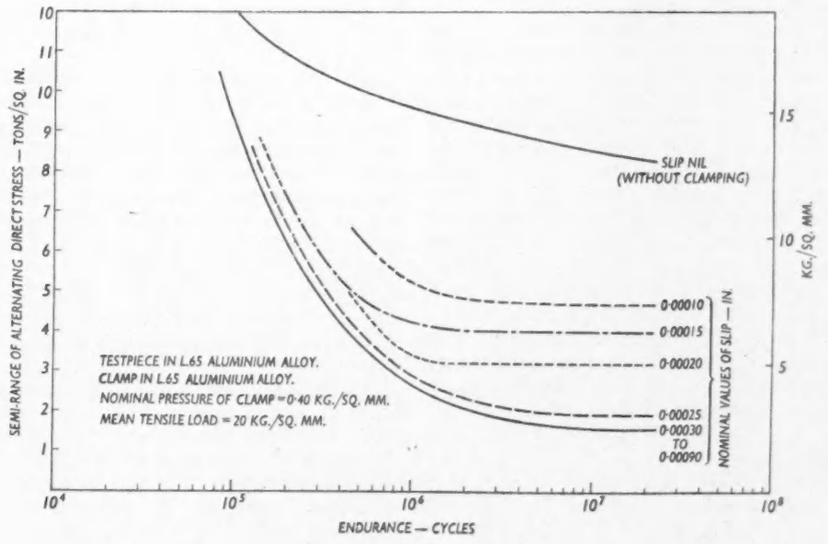


Fig. 4

§ *Iron Age*, September 12, 1940, page 37.
‖ *Revue de Métallurgie*, 1958, Vol. 55, page 475.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

RAILWAYS INTO ROADWAYS

SIR,—Mr. J. E. Allen in his letter on road and rail in your issue of September 12 repeats in different form the assertion he has made in other columns that ratepayers provide the roads and all that the road-user has to do is to provide the vehicle. He persists in ignoring the existence of road vehicle and fuel taxation, which now reaches the astronomical figure of over £500 million a year. Allowing for what is spent on roads, the general revenue benefits by some £450 million annually. Gratuitously-provided permanent way for road transport, indeed !

Mr. Allen's comparison of rubber tyred vehicles running on roads with steel tyred trains running on steel tracks is irrelevant. The internal combustion engine has a thermal efficiency some five times that of the steam locomotive, but that also is irrelevant. Relevancy lies in what determines choice in the use of transport, and that is the value the user places on the alternatives available to him. Annual spending on road transport and travel is four times that on rail transport and travel, excluding cost of vehicles and spending on roads. Yet, when it comes to modernising and maintaining roads, far less has been spent of roads than on British Railways' track since vesting date. Between 1948 and 1957 £91,000,000 in total was spent by the Government on new construction and major improvement of roads. This compares with the £209 million British Railways have been able to add to the book value of the railway track by new construction during that period. As regards maintenance of roads, at no time between 1948 and 1957 was the total maintenance expenditure on all roads in the country more than £75,000,000 yearly ; it was usually very much less, and was consistently lower than what British Railways have had to spend annually on maintenance of the track.

The £1500 million Railway Modernisation Plan, with its help from Government loans, includes money of the order of between £125 million and £200 million to be spent by 1962 on the track. I have no quarrel or reservations to make over this or any other part of the Plan—indeed, I wish it well if only because the British Transport Commission feel it will help them in dealing with their problems and because it is more than high time the field were left clear for grappling with the at least equally grave one of modernising our road system to 1975 standard.

It is absurd to go on interminably with untenable figures and arguments over relative expenditure. Here at least are figures which can be checked from indisputable sources.

C. D. MORGAN

Secretary,
British Road Federation,
26, Manchester Square,
London, W,1,
October 1, 1958.

SIR,—This Society is among the many that have followed with deep interest this weighty subject, and we would be grateful if we could add some points to the debate.

One thing that stands out is that few of the conversionists have much knowledge of the operation of any form of transport—certainly not the intimate knowledge and experience that is required to organise and run a railway, The idea of conversion is a fantasy of their minds, and they seize on any fact, however irrelevant, and produce any statistic, often quite meaningless, that might help to advance the scheme. Quite rightly you stated in an Editorial that the pro-railway faction seemed to be bogged down in a welter of sentimentality, but few solid facts were being produced. Subsequently the standard of correspondence from both sides improved, but the conversionists appear unable to produce much better than more and more figures which thinking people must realise are useless. Brigadier Lloyd of course, is a master of mathematical manipulation, and this method is used to attempt to blind the reader to all other facts and considerations.

However, this Society has made an objective study of *Twilight of the Railways*, and even after accepting the overweight of statistics and average figures (which are difficult to stomach in parts) we find too many points left open to speculation. Indeed, travel by bus on the converted railways would be largely a matter of speculation, as it is proposed to abolish timetables, and run buses only as required. Whilst we believe that a system of this nature applies in cities in the Middle East, it could hardly be applied to the whole of Britain. Not only would there be uncertainty of departure time, but one's arrival would be equally impossible to forecast. There is also mention of restaurant buses, but we cannot imagine how every bus would be fitted with a kitchen ; the amount of space remaining for seats would be so small as to make operation highly uneconomic. If only a proportion of buses are to be restaurant-fitted, when will one know when to catch one, if there are no timetables ?

Turning now to the peak-hour problem, Brigadier Lloyd cannot or will not accept the incredible surge of passengers entering and leaving London on weekdays. " Twilight " conveys the idea of passengers arriving in a steady trickle at each station at about the rate that a bus can load. We get the impression that everybody lives 12 miles from London, and that whilst there is a crowd to be lifted, it is not much of a problem. He then contrives to confuse the issue by quoting the average load of ninety on B.R's trains.

Clearly Lloyd has never visited one of London's termini in the rush hour, and does not know what is involved. For instance, Liverpool Street alone despatches eighty-five trains from 4.56 p.m. to 6.33 p.m. Monday to Friday, conveying on a typical day 50,834 passengers. To despatch this load in buses would require 848 60-seaters, leaving every 8¾ seconds. Assuming this headway were practicable (we doubt if any soul-respecting human would entrust himself to such operation) it is quite impossible for sixty people to board a bus in this time. In actual fact more than 848 buses would be required, as these passengers are heading for some sixty different destinations. It is a well-known fact that a lane of buses travelling non-stop at close headway can only manage 10,000 passengers per hour, and so Liverpool Street, with all the other stations in London, will have a dire shortage of transport. In fine, transport does not come in neat parcels as Lloyd believes, and only railways are capable of dealing with the problem.

As " Twilight " states that the worst place for the wheels of a bus is underneath, we would like to inquire where Lloyd proposes to put them. They cannot go outside the body, as there will not be room for them : the overall width would be too great. Presumably they must go on top !

At the League's rally recently, which we were privileged to attend, it was stated that the L.T.E. " Underground " system should not be converted to roadways. Whilst it was not said why, we can only assume that the R.C.L. recognise the contribution of these electric railways in handling London's traffic : but they ignore B.R's suburban electric railways, which provide similar services, and in many cases better, for on the Underground frequencies often fall off badly, there are only two cases of express operation, and the average speed is much lower. In any case two-thirds of the Underground is on or above the surface, and there is interworking with B.R. in a number of cases ; what does the League propose for these lines ? By admitting the need for the Underground they have admitted the need for a national railway system.

It would not be difficult to write a book twice as large as " Twilight " merely correcting its statements, let alone setting down the fundamentals of railway operation. But there is one matter which, standing alone, condemns the case for converting the railways. Whenever an accident occurs on a two-lane carriageway, a complete traffic block in both directions will follow, and it will be totally impossible for ambulances and other rescue teams to reach the scene. If Brigadier Lloyd wishes to theorise, and suggest the use of helicopters, or approach across fields, we would ask what happens when the accident is in a long tunnel, as many of them would be ? In a country where human life is held to a high value, we doubt if any Government would authorise a scheme whereby life was endangered to a tremendous degree, and thus we consider that railway conversion is an idea that is doomed to failure here, now, and forever more.

P. BRIXEY

Assistant Secretary,
Electric Traction Society,
16, Burchell Road,
Leyton, E.10,
October 1, 1958.

Book Reviews

Conformal Transformations in Electrical Engineering. By W. J. GIBBS. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 45s.

THE scope of the book is more limited than its title suggests. It is concerned only with the application of conformal mapping to field distribution problems and applications to circuit and transmission line theory, and other branches of electrical engineering are not considered. The main purpose, so the author tells us, is to provide a text which will enable engineers, not familiar with the subject, to appreciate and understand the important papers by F. W. Carter and by R. T. Coe and W. H. Taylor, which are classical in the field of electric machine design. There is no doubt that the book admirably fulfils this purpose. It begins with simple field problems and proceeds gradually to more difficult ones. All steps in the argument are discussed in detail and with clarity and there are included worked examples which have been carefully chosen to illustrate the applications. The second half of the book is devoted to transformations involving elliptic functions and in the final chapter the stage is reached for a full treatment of the magnetic field distribution of armature slots in a machine, which is one of the problems dealt with in the paper by Coe and Taylor.

The contents of the book are rendered more complete by the inclusion of a brief, but adequate, account of field theory and of complex numbers and variables. It is somewhat confusing, however, after defining a two-dimensional field (page 5) to use as an illustration of such a field a point charge, which gives rise to a three-dimensional field of the inverse square type. Also one misses the definition of an analytic function. Such functions are used throughout the book, but never mentioned by name. Since no definition is given of the derivation of a function of a complex variable, the argument on conjugate functions in Chapter 4 really begs the question. It is not true, as stated in this chapter, that the real and imaginary part of any function of a complex variable satisfies the Laplace equation. However, these are minor points in a book mainly intended for engineers and they do not detract from its value. The book is very lucidly written and its production and illustrations are very good. Although there are a number of misprints they are easily spotted and should cause no confusion. It is certain that the book will find a place on the shelves of engineers interested in this particular field.

Theory of Structural Analysis and Design. By JAMES MICHALOS. The Ronald Press Company, 15, East Twenty-Sixth Street, New York, 10, N.Y. Price 12.00 dollars.

BOOKS on the theory of structures are so numerous to-day that one wonders that anyone can find it worth while writing another. Yet new books are written and in increasing numbers. Generally, they have much in common and this makes the task of the reviewer easier, if at times a bit boring. In a subject where it is difficult to be original a good book is doubly welcome.

Professor Michalos's book deals with structural analysis in a comprehensive and thoroughly competent manner. It is not loaded, as is often the case, with a variety of subjects belonging more appropriately to the wider field of applied mechanics. The term "design" in the title must be understood in its fundamental engineering sense. The book does not set out to show how to detail a structure or a part of a structure once the stresses are known, but it does treat of the interdependence of structure and stress, and the intimate influence which the general conception of a structure has on the stresses generated therein. The book marries ably the new numerical methods of successive approximations to the classical methods of analysis. This will be particularly useful to the lecturer anxious to show the logical transition from the methods of Castigliano, Clapeyron and Maxwell to the Hardy Cross method. Much use is made of the elegant method of influence lines. Elastic arches, frames and columns are treated very thoroughly, but slabs are not discussed.

In short, the book deals most adequately with statically indeterminate structures of all kinds and will certainly appeal to lecturer, student and practising engineer.

Stabilisation des transports d'énergie à longue distance. By RENE PERRET. Publications Scientifiques et Techniques du Ministère de l'Air, No. N.T.75. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price Ffr.3300.

USING the basic electrostatic and electromagnetic equations, it is simple to set up the equations of a network comprising rotary machines and non-moving elements. The difficulty lies in the large number of coefficients which are normally involved. These, according to their nature, can be arranged in the form of resistance, inductance and capacitance matrices, which thus represent the structure of the network and determine its properties. The present book deals with the structure of these matrices and applies to them a transformation analogous to that of Fortescue. This results in obtaining for any regime the simplifications which are possible with symmetrical co-ordinates under steady state conditions. In the following chapters the author deals more especially with rotating machines and the meshes of the network. Further consideration reveals the existence of a whole group of transformations, to which the techniques of the tensor calculus are applied. The first section concludes with a study of lines with distributed constants, and shows how the theory may be applied to the stability of long-distance energy transmission.

The second section deals with analogue computation as applied to the present range of problems. In the final section, the author reports on experimental work carried out by means of network models.

Electric Technology, U.S.S.R. Volume I, May, 1958. Selected papers from *Elektrichestvo*, Nos. 1–4, 1957. Pergamon Press, Ltd., 4 and 5, Fitzroy Square, London, W.1. Price 120s.

WITHIN the framework of the large-scale engineering effort which has been made in the Soviet Union since the war, electrical technology has played an important part, as, indeed, it has done since the 1920s. Mention may be made of d.c. power transmission, high voltage a.c. transmission, the development of water power, and contributions to the theory of automatic control and remote control. For those unable to read the originals, selected papers from the general electrotechnical Russian journal *Elektrichestvo* are being published by Pergamon Press. These in the main cover technical and economical aspects of heavy current engineering, but generally exclude radio and telecommunications. Reprints of any articles from *Elektrichestvo* can be obtained on application at a price of 10s. The translated version will be published in the form of four volumes per annum.

Methodes theoriques d'etude des ecoulements supersoniques. By P. CARRIERE. Publications Scientifiques et Techniques du Ministère de l'Air, No. 339. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price Ffr.3000.

IT is barely fifteen years that the theory of non-viscous supersonic flow has been extended from the simple cases of plane and conical flow. The author expounds the theory and method of calculation for more general cases, starting from the method of characteristics, and without linearising the equations first. These procedures can be extended to three-dimensional problems which do not depart too much from the two-dimensional case, but the lengthy calculations required have led to a search for formal solutions obtainable if the equations are first linearised. Starting thus from an approximation, the accuracy of such solutions, though generally good, is usually insufficient when the local values of physical quantities have to be calculated. The author presents a synthesis of these methods with the extensive numerical procedure which, by the use of electronic calculation machines, can be divested of much of its forbidding complexity. An original contribution is his discussion of the properties of curvature of shock waves.

Cinétique du développement d'un gros cristal dans la méthode de l'allongement critique. By HENRI LATIERE. Publications Scientifiques et Techniques du Ministère de l'Air, No. 342. Service de Documentation et d'Information Technique de l'Aéronautique, Magasin C.T.O., 2, Avenue de la Porte-d'Issy, Paris (15e). Price Ffr. 1950.

A NUMBER of interesting results concerning the growth of large monocrystals were obtained by means of a twin-film camera which permitted a continuous X-ray study and avoided the disturbances to crystal growth resulting from interruptions in the heat-treatment. A stereoscopic device made it possible to determine rapidly the grain directions on the basis of the resulting Laue diagrams.

Books Received

The Efficient Use of Fuel. Second edition. H.M. Stationery Office. Price 35s.

Technical Editing. Edited by B. H. Weil. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 46s.

Atomic Energy. By Egon Larsen. George G. Harrap and Co., Ltd., 182, High Holborn, London, W.C.1. Price 12s. 6d.

Circuit Analysis of Transmission Lines. By J. L. Stewart. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 44s.

Effect of Surface on the Behaviour of Metals. The Institution of Metallurgists, 4, Grosvenor Gardens, London, S.W.1. Price 21s.

Automatic Control. By Werner G. Holzbock. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 60s.

Automatic Process Control. By D. P. Eckman. Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 72s.

The Solid State for Engineers. By M. J. Sinnott Chapman and Hall, Ltd., 37, Essex Street, Strand, London, W.C.2. Price 100s.

Proceedings of the Second Symposium on Concrete Shell Roof Construction, 1–3 July, 1957. Teknisk Ukeblad, Kronprinsensgt. 17, Oslo 9, Norway. Price 107s.

Garcke's Manual of Electricity Supply. Vol. 55. 1957–58 Edition. Edited by F. C. Garrett. Electrical Press, Ltd., 19–20, Noel Street, London, W.1. Price 80s.

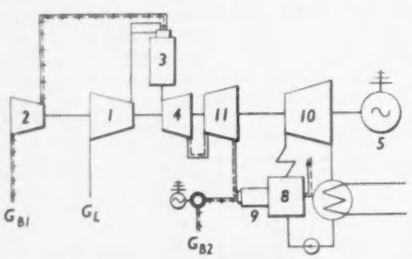
Fourth National Symposium on Vacuum Technology Transactions. Edited by Wilfred G. Matheson. Pergamon Press, Ltd., 4 and 5, Fitzroy Square, London, W.1. Price 90s.

Steam-Gas Cycle with Additional Combustion

Abstracts are reproduced here from one of the papers presented at the recent Sectional Meeting of the World Power Conference in Montreal. The author of the paper is Mr. V. Kral, a mechanical engineer at the Skoda Works in Czechoslovakia. Advantages of combining gas and steam turbine cycles were pointed out at the conference. Here a series combination is described, and its properties deduced. Tests on a 4·4MW pilot plant using this cycle have been carried out, and the design of a 50MW set has been based on the results achieved.

IN the working cycle shown in the diagram the air compressor 1 takes air in quantity G_L from the atmosphere and delivers it to the combustion chamber 3. Fuel in quantity G_{B1} is delivered to the combustion chamber either by the gas compressor 2 or by a liquid fuel pump. The combustion products flow from the combustion chamber into the turbine 4 driving the compressors. From the turbine 4 the gases flow into the low-pressure turbine 11 which, together with a steam turbine, drives the alternator 5. From the low-pressure gas turbine the combustion products flow through the additional combustion chamber 9 into the boiler 8. Fuel in quantity G_{L2} is delivered to the additional combustion chamber either by a fan or a pump. The set 1 to 4 is balanced and its speed depends on the load of the whole steam-gas unit. By dividing the gas turbine into turbines 4 and 11, very economic control of the whole gas-steam unit is attained due to speed control of the set 1 to 4.

The additional combustion chamber is



Schematic diagram of a steam-gas cycle with additional combustion

fitted with two burners. One of them delivers the heat for steam superheating, while the other one serves to raise the inlet temperature of the gases entering the boiler, thus controlling the boiler output. By a proper adjustment of the two burners, constant temperature of the superheated steam can be obtained irrespective of the load of the unit.

Let us determine the basic characteristics of this steam-gas cycle shown under the following assumptions :

Air condition at compressor intake ... ... 1 atm. 15 deg. Cent.
Compressor internal efficiency ... ... $\tau_{ik}=0{\cdot}85$
Turbine internal efficiency $\tau_{tb}=0{\cdot}88$
Mechanical efficiency of both turbine and compressor ... ... $\tau_{in}=0{\cdot}99$
Combustion efficiency at constant volume (in both combustion chambers) ... ... $\tau_{vF}=0{\cdot}99$
Hydraulic losses in combustion chamber 3 ... $=0{\cdot}3$ Cal./kg
Hydraulic losses in ducting... ... ... $=0{\cdot}3$ Cal./kg
Hydraulic losses in boiler $=0{\cdot}4$ Cal./kg
Efficiency of thermal insulation of gas turbine and boiler ... ... $\tau_{is}=0{\cdot}99$
Specific energy consumption of fan delivering fuel for additional combustion ... ... $=0{\cdot}15$ Cal./kg
Efficiency of 25MW alternator (bearing losses included) ... ... $\tau_{ta}=0{\cdot}967$
Efficiency of 50MW alternator (bearing losses included) ... ... $\tau_{ta}=0{\cdot}9784$

The steam condition depends on the character of the power station. In peak-load stations, the steam condition of 35 atm., 435 deg. Cent. at the turbine starting valve (38 atm., 450 deg. Cent. at the superheater outlet) is advantageous for economical and operational reasons.

Adiabatic efficiency at the coupling of a standard 25MW steam turbine ... ... $\tau_{tad}=0{\cdot}81$
Adiabatic efficiency at the coupling of a standard 50MW unit ... $\tau_{tad}=0{\cdot}84$

In more economical power stations, the steam condition of 90 atm., 535 deg. Cent. at the turbine starting valve (96 atm., 540 deg. Cent. at the superheater outlet) is preferable.

Adiabatic efficiency at the coupling of a standard 25MW unit ... $\tau_{tad}=0{\cdot}79$
Adiabatic efficiency at the coupling of a standard 50MW unit ... $\tau_{tad}=0{\cdot}82$

For highly economical power stations, the steam condition of 135 atm., 565 deg. Cent. at the turbine starting valve (145 atm., 575 deg. Cent. at the superheater outlet) are recommended.

Adiabatic efficiency at the coupling of a standard 25MW unit ... $\tau_{tad}=0{\cdot}78$
Adiabatic efficiency at the coupling of a standard 50MW unit ... $\tau_{tad}=0{\cdot}81$

A back pressure of 0·05 atm. is uniformly assumed for all the turbines.

Consumption of auxiliaries :

At boiler pressure, atm.	38·0	96·0	145·0
Per cent of alternator output, a	6·5	7·5	8·0

A pressure loss of 11 per cent of boiler drum pressure was assumed in the superheater for all live steam conditions quoted above.

The overall efficiency of a steam-gas power station at the alternator terminals :

$$\tau_{iv}=\frac{G_{B1}\,.\,\tau_{iu}\,.\,\tau_{iGT}+[(G_{B1}+G_L)\,.\,i^1{}_2+G_{B2}\,.\,h_u\,.\,\tau_{iF}](1-a)\,.\,\tau_{itd}}{(G_{B1}+G_{B2})\,.\,h_u} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where :

τ_{iGT} = efficiency of the energy generation in the gas cycle, from the heat supplied to the combustion chamber to the alternator terminals.
τ_{itd} = thermodynamic efficiency of the steam cycle from the heat supplied to the boiler to the alternator terminals.
$1'_2$ = enthalpy of combustion products from turbine 11 at the afterburner chamber inlet.
h_u = net calorific value of fuel.

Let us denote the relative amount of fuel burnt in the afterburner as follows :

$$\delta'=1+\frac{G_{B2}}{G_{B1}}\,.$$

Then the overall efficiency of a steam-gas power unit (from fuel to alternator terminals) will be :

$$\tau_{iv}=\frac{\tau_{iGT}+\left(\delta'-\frac{\tau_{iGT}}{\tau_{in}\,.\,\tau_{ia}\,.\,\tau_{iF}}\right)\,.\,(1-a)\,.\,\tau_{itd}}{\delta'} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The relative share of the gas turbine in the output of the steam-gas unit is :

$$\varepsilon=\frac{N_{GT}}{N_{GT}+N_{DT}}=\frac{\tau_{iGT}}{\delta'\,.\,\tau_{iv}} \quad . \quad . \quad (3)$$

where :

N_{GT} = net output of the gas turbine at the alternator terminals.
N_{DT} = net output of the steam turbine at the alternator terminals.

For a practically feasible operation, the temperature of combustion products at the end of the economiser must be higher than the boiling temperature of water in the boiler. In calculating the lower limit value of δ', a 30 deg. Cent. difference between the temperature of the combustion products and that of water at the beginning of the boiling section is assumed, and the equation of heat balance of the boiling section and the superheater as well as equation (1) is used.

From the relations involved, δ'_{min} results as :

$$\delta'_{min}=\frac{\frac{i'_2}{860}\cdot\frac{\tau_{iGT}\,.\,q}{\tau_{iF}}-A\left(1-\frac{\tau_{iGT}}{\tau_{in}\,.\,\tau_{iF}\,.\,\tau_{ia}}\right)}{A-\frac{i_2}{\tau_{iu}\,.\,\tau_{iF}}}+1 \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where :

$$A=\frac{\tau_{itd}}{\tau_{is}\,.\,\tau_{iF}\,.\,\tau_{tad}\,.\,(1-a)}\cdot\frac{i_{DK}-i_w}{i_{DT}-i_{2ad}}$$

i_{DK} = steam enthalpy at the boiler, in kcal/kg.
i_{DT} = steam enthalpy at the turbine starting valve.
i_{2ad} = steam enthalpy at the end of adiabatic expansion from the condition at the starting valve to a back-pressure of 0·05 atm., and
q = spec. air quantity per 1kWh of gas turbine output at the coupling, in kg/kWh.

The maximum amount of fuel burnt in the afterburner chamber is limited by the oxidising ability of the turbine exhaust gases.

The theoretical air consumption for combustion of :

1kg of blast-furnace gas ... $b=0{\cdot}75$kg/kg.
1kg of fuel oil... ... ... $b=15$kg/kg.
1kg of natural gas ... ... $b=17$kg/kg.

The following condition applies for the theoretical utilisation of all oxygen present in the exhaust gases for combustion in the afterburner chamber :

$$G_L=b(G_{B1}+G_{B2})$$

$$\delta'_{max}=\frac{\tau_{iGT}\,.\,q\,.\,h_u}{860\,.\,b}\,.$$

Since the combustion in the afterburner

chamber takes place in a medium of lower oxygen content than that in the air, the practically obtainable multiple δ' will be smaller than δ'_{max} because it is limited by the possibility of continuous combustion in a medium of lower oxygen concentration.

δ'_{max} depends on the fuel, the compression ratio, and the temperature ahead of the gas turbine. For poor fuels and a temperature at the gas turbine inlet t_{1G}=650 deg. Cent. and a compression ratio from 3 to 6, the value of δ'_{max} is 6 to 8·6 ; for t_{1G}=800 deg. Cent. and a compression ratio of 3 to 6 it is 5 to 6·5 for both the present and the future turbo-machine efficiencies. The lowest values of δ'_{max} are valid for natural gas : for t_{1G}=650 deg. Cent. and a compression ratio of from 3 to 6, δ'_{max}=3·75 to 5, and for t_{1G}=800 deg. Cent. and a compression ratio of from 3 to 6, δ'_{max} 3·2 to 4. For heavy liquid fuels and for t_{1G}=650 deg. Cent., δ'_{max} varies within the limits of 4·77 to 6·9 for the present-day and also for better turbo-machine efficiencies. Practical values will remain somewhere in the vicinity of maximum efficiency τ_{iv} and are considerably lower than δ'_{max}.

The following conclusions may be drawn from graphs showing the dependence of τ_{iv} and ε on δ'.

(1) With the present technical means and usual materials limiting the inlet gas temperature to 650 deg. Cent. and with turbo-machine efficiencies of τ_{ik}=0·85 and τ_{ub}=0·88, it is possible to achieve in a combined gas-steam cycle higher overall efficiencies than in a straight gas cycle, even at the relatively low steam inlet condition of 35 atm., 435 deg. Cent. The gas turbine delivers one-fifth to one-tenth of the total output of the gas-steam unit.

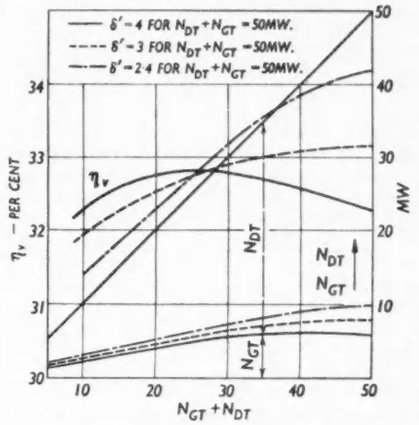
The optimum overall efficiency increases with raising the steam inlet condition (from 31·8 per cent at low steam condition up to 34·9 per cent at economic steam condition). The influence of advancing steam conditions on the optimum efficiency of a gas-steam unit is less pronounced than in the case of straight steam units (10 per cent as against 15 per cent for the steam conditions chosen).

(2) Steam-gas units with a simple gas turbine can achieve outputs from five to ten times larger than the present-day limiting output of open straight gas cycles at an efficiency higher than that obtainable by a gas cycle. The gas-steam set is practically as intricate as a straight steam set (feed water regenerative heating and air heating in the boiler being eliminated), but it is more complicated than a straight gas cycle. The control of a steam-gas cycle is not more complicated than that of a straight steam cycle, neither is it more intricate than the control of cycles with intermediate cooling and heating. Compared with a straight steam unit of equal capacity, the consumption of cooling water of a gas-steam unit is less in the same proportion as the capacity of its steam component is less than that of the straight steam unit. A straight air cycle with intermediate cooling has a water consumption of 150 cubic metres per megawatt hour, which is 2·5 to three times less than that of a gas-steam unit. Under certain conditions, the water consumption may become the decisive factor in favour of the straight air cycle against the gas-steam unit.

(3) A gas-steam unit has a higher efficiency than a comparable straight steam unit. So, for instance, a 50MW steam set at the steam inlet condition of 90 atm., 530 deg. Cent., with feed water heating up to 220 deg. Cent., has an overall efficiency (from fuel to alternator terminals) of 31 per cent when burning gaseous or liquid fuels. The optimum efficiency of a 50MW gas-steam set at the same steam inlet condition of 90 atm., 530 deg. Cent. is 34·2 per cent.

(4) The overall efficiency of a gas-steam unit η_v varies only slightly with the quantity of fuel burnt, so that such a unit meets well the basic requirement of a power station handling substantially variable loads. Owing to this feature, inherent to gas-steam sets, it is possible to select an economic installation for loads even lower than 50 per cent of the rated output of the unit.

As can be seen from the second diagram (herewith) the overall efficiency curve of a



Dependence of efficiency of steam-gas cycle on load

gas-steam unit depends in particular on the relative quantity of fuel δ' at the rated output. At δ'=4, a very flat curve of efficiency at partial loads can be noticed. In a gas-steam cycle designed for maximum economy at full output, the drop in efficiency is less than with a straight steam unit and is more favourable than the efficiency drop in a straight gas cycle of the same rated output. For both the cases under consideration, the illustration shows also the curves of outputs of the gas and steam turbines, respectively.

From the standpoint of capital investment, a power station of this kind is very attractive, since the possibility of raising the output up to twice or more the rated output with an optimum thermal efficiency is obtained at the price of a moderate increase in the production costs of the steam turbine with accessories and of the alternator. The readiness to meet substantially variable load demands is very high, since a gas turbine operates practically at sustained gas conditions regardless of the load, and the output of the steam boiler can be more rapidly controlled by suitably adjusting both burners in the afterburner chamber.

(5) The optimum compression ratio for attaining maximum efficiency is 5 to 6, according to the kind of fuel used. The amount of fuel burnt in the afterburner chamber under optimum service conditions is about the same as in a gas turbine combustion chamber utilising rich fuels. With poor fuels, the quantity burnt in the afterburner chamber at optimum efficiency is about twice as large as in the gas turbine combustion chamber. Optimum efficiencies of gas-steam units when burning rich fuels are better by a factor of 1·03 than when burning poor fuels, due to lower stack loss.

(6) The efficiency drop at partial loads is caused by the steam component as the efficiency of the gas turbine is practically constant. The efficiency of the 25MW gas-steam unit is less by a factor of 1·03–1·04 than that of the 50MW unit, and the drop is smaller than with straight steam units.

(7) An increase in the temperature of gases entering the turbine from 650 deg. up to 800 deg. Cent. at the same steam condition results in a 6 per cent relative increase in the optimum efficiency of the steam-gas unit for all live steam conditions compared. The relative increase in the optimum efficiency due to temperature increase is three times lower in a gas-steam unit than in a straight gas unit. The quantity of fuel burnt in the afterburner chamber at optimum efficiency decreases to 70–75 per cent of the values corresponding to t_{1G}=650 deg. Cent. The optimum compression ratio increases to 6 for the temperature increase mentioned.

(8) An improvement of the aerodynamic qualities raises the optimum efficiency to 40·1 per cent, i.e. by a factor of 1·07 at 650 deg. Cent. and steam inlet condition of 135 atm., 565 deg. Cent. With turbo-machine efficiencies of to-day, this improvement has, in the present case, practically the same consequence as the increase of gas inlet temperature from 650 deg. to 800 deg. Cent. Its influence is half as marked as with a straight gas cycle. The amount of fuel burnt in the afterburner chamber at optimum efficiency is independent of the turbo-machine efficiency. With better efficiencies of the compressor and turbines, the relative load of the gas turbine has grown by 13 per cent. The optimum compression ratio rises to 6. The increase in the inlet gas temperature from 650 deg. to 800 deg. Cent. results in a better efficiency of the compressor and turbines, but, on the other hand, in a lower relative efficiency improvement (two times) with the gas-steam cycle than with a straight gas cycle. A comparison of the optimum efficiencies of a steam-gas cycle with those of the gas cycle of large units 2–2–0·75 (two-stage inter-cooling, two-stage combustion, 0·75 regeneration efficiency) will show that with the present turbo-machine efficiencies and t_{1G}=650 deg. Cent., the gas-steam cycle affords an optimum efficiency higher by the factor 1·13. With to-day's turbo-machine efficiencies, the gas-steam cycle operating at a gas inlet temperature of 800 deg. Cent. and steam inlet condition of 135 atm., 565 deg. Cent., is equivalent to the gas cycle 2–2–0·75 operating at a gas temperature of 800 deg. Cent. at the outlet of both combustion chambers.

With future turbo-machine efficiencies and with t_{1G}=650 deg. Cent., the efficiency of a gas-steam cycle is by 5 per cent better than that of the cycle 2–2–0·75, and at t_{1G}=800 deg. Cent. ahead of the high-pressure and low-pressure turbines, the cycle 2–2–0·75 is better by 4 per cent than the steam-gas cycle with t_{1G}=800 deg. Cent. and steam condition of 135 atm., 565 deg. Cent. This fact is caused by the relative low steam temperatures in the two cases compared.

The possibility of improving the gas-steam cycle efficiency is in close connection with the improvement of the efficiency of the steam and gas components and with lowering the temperature difference between the combustion products and the boiling temperature at the end of the economiser to a value less than that considered above (30 deg. Cent.). Such a smaller difference has a limited significance at low values of δ' only at which the introduction of a second steam pressure into a low turbine stage would also be useful. At values of δ' higher than 2 or 2·5, it is of advantage to reduce the temperature of the combustion products entering the stack to an economic value by inserting suitable heat-transfer surfaces, thereby improving the overall efficiency of the cycle.

Another possibility of improving the thermal efficiency of a gas-steam unit is the

introduction of intermediate cooling and combustion into the gas cycle and reheat into the steam cycle. These modifications lead to multi-shaft gas turbines and complex steam turbines. Such complicated cycles with efficiencies of 39 to 41 per cent can be economically justified only if unit capacities of more than 100MW are in question.

In order to gain fundamental data on which to develop and construct power unit operating on the highly economical cycles discussed above, the Skoda Works has, in test, run a 4·4MW gas-steam pilot unit. Although the gas and steam conditions in both cycles had to be different from the optimum ones, a 28 per cent overall efficiency has been obtained with this relatively small unit, and the outstanding operational and economic features of combined gas-steam cycles stressed in this paper have been so far confirmed. On the experience gained with this pilot plant, a 50MW steam-gas unit has been designed. Both the gas and the steam turbines are arranged on one common shaft. Alternatively, a cross-compound arrangement is possible, the compressor turbine, together with the air and gas compressors and the starting motor forming one set, the l.p. gas turbine, the steam turbine and alternator the other. Final arrangement would depend on local conditions and on the number of units in the engine-room. A steam-gas set without regenerative feed water heaters is more easy to arrange than a standard steam turbine set.

With the inlet gas and steam conditions conventional to-day, the proposed gas-steam cycle has in the 50MW unit an overall efficiency of 35 per cent. As compared with other present-day methods of increasing thermal efficiency, the technical risk of a gas-steam cycle is the least. The efficiencies attained in a steam-gas cycle are higher than those in straight steam or straight gas cycles. As the steam-gas cycle utilises all the technical improvements in the design of components of both the gas and steam cycles, the efficiency of energy conversion in a steam-gas cycle will in future—supposing comparable cases—always be higher than that in straight steam or straight gas cycles.

The very flat efficiency curve is of particular advantage for units handling highly variable loads or for economical utilisation of variable surpluses of blast-furnace gas in metallurgical works.

The steam turbine load varying within wide limits calls for special design of the machine such as to render its efficiency curve as flat as possible. Its full-load efficiency is, of course, slightly worse, which fact has been respected when assessing other efficiencies thereby affected. It will be convenient to divide at least the major auxiliaries into two units and, at low loads, to keep only one of them running. The power demand of the auxiliaries has purposely been chosen rather high.

The proposed gas-steam cycle is very advantageous for power plants burning gaseous or liquid fuels. For power stations operating on solid fuels as main fuels, and on gaseous or heavy liquid fuels as additional fuels, the steam-gas cycle affords a possibility of a more perfect utilisation of these fuels than that commonly achieved to-day in straight steam cycles. By full-scale application of elements at present being developed in laboratories, it will be possible, in the near future, to achieve in 50MW gas-steam units overall efficiencies of 40 per cent, even when using simple steam and gas cycles.

Controlled Thermonuclear Research in the United Kingdom

On pages 585–587 of this issue our American Editor describes the progress of Controlled Thermonuclear Research in the United States of America. Great Britain's contribution to research in this field was discussed by Dr. P. C. Thonemann at the conference on "Atoms for Peace," which was held in Geneva last month. Abstracts from Dr. Thonemann's paper are given here.*

Historical

THE possibility of utilising the energy released in nuclear reactions between the light elements was probably first discussed at the Cavendish Laboratory, Cambridge, in 1932. It was at this time that Lord Rutherford and his colleagues demonstrated that artificial nuclear reactions could be produced in the laboratory and that energy was released in each nuclear event. These reactions were produced by accelerating positive ions or nuclei to high velocities using potential differences of hundreds of kilovolts and firing them at a target containing the other elements. At low bombarding energies these reactions were found to be most probable with the light elements. No direct application of their discoveries for power generation was foreseen ; in fact Lord Rutherford described such speculations as "moonshine." At best only 1 in 10^5 of the bombarding particles reacted with a target nuclei, the remainder being brought to rest by unproductive energy losses to the target atoms.

The concept of thermonuclear reactions providing the energy radiated by the stars was clearly put forward by Atkinson and Houtermans[1] in 1928, but no suggestions for achieving a similar energy source on a terrestrial scale were seriously considered in the United Kingdom until 1946.

It was clear that the high temperatures necessary could not be reached unless some means was devised for keeping the hot gas away from the walls of the containing vessel. Experimental investigation of the confinement of a hot electrically conducting gas by magnetic fields was started by Sir George Thomson in London in 1947 and by myself in Oxford in 1948. These independent programmes attracted Government support in 1948 and continued in the two Universities until 1951.

Several possible magnetic field configurations were studied in relation to toroidal tubes but confinement by the self magnetic field of a current flowing in a gas appeared the most promising. Some of the results of this early work were published in 1951.[2,3] In 1951 the London group moved to the Research Laboratory of Associated Electrical Industries, Aldermaston, and the Oxford group to Harwell. A small team at the Atomic Weapons Research Establishment began in 1956 to pay special attention to the interesting features of the dynamic pinch.

It will be appreciated that this subject involves almost the whole range of classical physics included in the electromagnetic spectrum—from steady electrical currents to X-rays. Measurements of ionisation and excitation cross-section of multiply charged ions are now required together with further development in the basic theory of particle transport processes and in the new subject of magneto-hydrodynamics. Perhaps it is not surprising that progress is lower than one would wish.

We have now reached the stage of producing deuterium plasmas at temperatures in excess of 10^6 deg. K for appreciable intervals of time. At these temperatures we can study some of the phenomena which are likely to occur in a fusion reactor. Whilst other approaches to the problem of producing and maintaining a very high temperature gas will undoubtedly be described to this Conference, research in the United Kingdom has been devoted to a study of gas confinement by the "pinch effect," that is confinement by the magnetic field which accompanies an axial flow of current through the gas. Many other possible methods have been studied at earlier times but none appeared so promising.

The size of the apparatus employed depends to a large extent on the time for which the electrical currents are required to pass through the gas. Thus the group at the Atomic Weapons Establishment are interested in extremely short times and a rapid increase in discharge current. The essential feature of the equipment lies in the use of a large number of separate switches (spark gaps), synchronously triggered so as to connect in a parallel arrangement the large number of condensers that form the total bank. This reduces the inductance of the circuit external to the discharge to a very low value. At the other end of the time scale is the "Zeta" apparatus at Harwell. The discharge in the gas takes place in a toroidal vessel for longer periods of time and at much lower gas densities. In between these two extremes is the "Sceptre" device at the Research Laboratory of Associated Electrical Industries which is similar to "Zeta" but which has a more rapid rate of current rise.

The Basic Fusion Process

In order that a nuclear reaction takes place between two charged nuclei these particles must be brought close together against the coulomb repulsion of like charges. As an example consider the fusion of two nuclei of deuterium or heavy hydrogen. When the nuclei approach within the range of the attracting nuclear forces, about 10^{-13}cm, we can speak of a compound nucleus of two neutrons and two protons. This nucleus is similar to that of ordinary helium.

The compound nucleus can break up in the three ways described by the following equations—

$$H_1^2 + H_1^2 \rightarrow (He_2^4) \begin{cases} \rightarrow He_2^3 + n_0^1 + 3{\cdot}25\ \text{MeV} \\ \rightarrow H_1^3 + H_1^1 + 4{\cdot}03\ \text{MeV} \\ \rightarrow H_1^2 + H_1^2 \end{cases}$$

In the first two cases the new nuclei helium 3 and tritium are formed. The third case corresponds to simple elastic scattering and no energy is released.

Because three of the attracting nuclear particles come much closer together, forming a new stable configuration, the fourth is ejected with the energy difference. This

* U.K. Atomic Energy Authority, A.E.R.E., Harwell.

energy difference ΔE may be calculated from the mass difference ΔM between the initial and final nuclei taking part, according to the well-known equation $\Delta E = \Delta MC^2$.

At the particle energies of interest in thermonuclear research the probability of elastic nuclear scattering is much greater than the probability of a nuclear reaction. On the average, therefore, a fuel nucleus will make many elastic collisions with other nuclei before a reaction occurs and any ordered motion initially present will be completely disorganised before appreciable energy is released. For this reason a fusion power source will almost inevitably be a thermonuclear process since nuclear reactions take place as a result of impacts between particles with thermal or random motion.

To calculate the minimum temperatures required for a net energy gain the conditions under which a high temperature gas can be confined must be discussed in more detail. It is essential that there is an equal concentration of negative and positive charges otherwise the resultant electric fields would be so enormous that confinement would be impossible. The presence of electrons leads to electromagnetic radiation due to the acceleration of electrons as they are deflected by the positive nuclei. This radiation escapes without absorption in the tenuous gas and no radiative equilibrium is possible. The energy radiated is many orders of magnitude less than that from a black body at the same temperature.

Consider a cycle in which electrical energy is used to heat the gas and maintain it at a high temperature. Energy must be supplied continuously to make up the radiation loss. This energy can only be recovered as heat and some 70 per cent is lost in the conversion of this heat back to electrical energy. To make up the deficit the energy released by nuclear fusion must be at least twice the energy radiated. Both the energy radiated and the nuclear energy released can be calculated. The minimum temperature turns out to be about 3×10^7 deg. K for a deuterium-tritium mixture and 3×10^8 deg. K from pure deuterium fuel. At these temperatures the fuel nuclei have energies corresponding to about 3 keV and 30 keV. This is small compared to that attainable in modern particle accelerators. The difference lies in the much higher particle densities necessary and the requirement of confining the particles in spite of repeated collision.

The margin between success and failure is narrow. Under the best conditions the rate at which deuterium gas produces nuclear energy is only about ten times the rate of radiation from the same gas. For a tritium-deuterium mixture the factor is a hundred and it is likely that the first successful fusion reactor will employ this fuel. At the present time the use of other fuels apart from the hydrogen isotopes appears to be excluded, first by the enhanced radiation due to the higher nuclear charge and secondly by the slower reaction rates.

The previous discussion has assumed that the charged particles, nuclei of deuterium and electrons, are perfectly confined and only electromagnetic radiation reaches the walls of the surrounding vessel. It is the problem of particle containment which is the principal stumbling block at the present time. Gravitational fields are not available and the next best thing is a magnetic field. Whilst it is possible in principle, to confine a high temperature plasma by rapidly oscillating electric fields[4] all methods studied experimentally in the United Kingdom have employed strong magnetic fields.

A high-temperature gas is a good electrical conductor due to the free electrons. The force acting on an element of the gas, carrying an electric current normal to a magnetic field, can be used to balance the kinetic pressure of the gas, $p=nkT$.

The current density in the plasma may be produced by an external e.m.f. or it may result from the slow expansion or diffusion of the charged particles across the magnetic lines of force. In the latter case new energetic particles must be introduced to maintain a steady state. There are several possible solutions but all must satisfy two conditions. First the net force acting on the gas as a whole is zero. Second, any displacement of the gas from a position of equilibrium must lead to a restoring force.

This restoring force must be produced by the interaction of electrical currents in the plasma and currents in external conductors, because forces due to particles striking the walls are to be made zero. The first condition is satisfied by the magnetic field associated with the flow of current in a cylindrical conductor and gives rise to confinement of the plasma by the pinch effect. The second condition is satisfied by enclosing the current channel in a cylindrical conductor. Any displacement of the current channel away from the axis of the cylinder results in currents in the outer conductor which, by Lenz's law, oppose the motion. Both the "Zeta" and "Sceptre" experiments have employed this principle.

Instability

The greatest difficulties we have experienced in reaching high temperatures is the instability of a magnetically confined plasma. Satisfying the above conditions only ensures that the plasma as a whole is in stable equilibrium but tells us nothing about the behaviour of a local deformation.

Charged particles moving in a static magnetic field can only cross lines of force between regions of different magnetic fields strength as a result of collision or longer range electric fields. Collisions with other particles are unavoidable, and the rate of diffusion to the tube walls is not prohibitive in most cases of practical interest. The effect of longer range electric fields is much more serious. I do not refer to those electric fields which are responsible for ordered current flow in the plasma but to local electric fields arising from charge separation or by magnetic induction. If an electric field exists normal to the confining magnetic field, plasma may flow across the lines of force at a velocity given by $v=ec/B$. Thus a random fluctuating electric field will allow a plasma element to make a random walk with the above speed and it will drift steadily away from its starting point across the lines of force.

Many magnetic field configurations have been suggested as a means of achieving stability and the search is still in progress. The theoretical work of Shafranov,[5] Tayler,[6] Bickerton[7] and Rosenbluth[8] on the pinched discharge stabilised by an axial magnetic field has guided the experiments in the United Kingdom, but I cannot say that we have achieved the configuration demanded by the theoreticians nor can they say they understand the stability achieved in the "Zeta" and "Sceptre" experiments.

The United Kingdom Contribution

The principal United Kingdom contributions to this conference are concerned with the results of the "Zeta" and "Sceptre" experiments and the fast pinch experiments in straight tubes at the Atomic Weapons Research Establishment.

Preliminary results obtained at Harwell and the laboratories of A.E.I. have already been reported.[9] Both experiments are essentially high current discharges in toroidal metal vacuum vessels in which an axial magnetic field is used to provide stability. Since the earlier reports, efforts have been made to understand the manner in which the current channel is formed, and to explain the stability.[10,11,12] Measurement of ion energies, X-rays and neutron intensities have been extended, and the role played by impurities investigated.

The A.W.R.E. group has studied the effect of rate of current rise on discharge properties as well as the effect of an axial magnetic field and impurities. They have observed some new phenomena.

The theoretical investigations to be reported are concerned with the structure of hydromagnetic shock waves in a fully ionised gas and with the stability of a magnetically confined plasma. The first subject is of importance in fusion research because shock waves provide a powerful mechanism communicating energy to positive ions even when collisions are few. It is very likely that the transfer of energy by binary collision between electron and positive ions will be too slow to reach fusion temperatures in the times required.

The importance of the second subject has already been pointed out. The principal theoretical objective is to devise an ideal model in which particles cannot reach the vessel walls because of instabilities. This does not mean that instabilities should be completely suppressed but that their amplitude must be limited.

The emission of impurities from the walls of the containing vessel play an important role both in the amount of energy radiated by the gas and in determining the magnetic field configuration. When the walls are conducting the formation of arc spots and vaporisation of wall material is a potent source of impurities. The mechanism of arc formation has been studied as well as the motion of arc spots in magnetic fields. Investigations on both these aspects will be reported.

Future Trends

I now turn to the future of research in the controlled fusion field. To my mind the problem of stability is of paramount importance. Unless the rate at which charged particles cross magnetic lines of force can be reduced to that given by classical diffusion theory the loss of energy to the walls will prevent a fusion reaction becoming a practical power source. A decrease in the energy flux to the walls by particle bombardment also reduces the amount of impurities thrown in the plasma and this in turn reduces the energy loss by radiation.

Assuming the stability problems are solved, it is estimated that currents of about 10,000,000A will be required in a tritium-deuterium mixture before a net balance of power is achieved using self-magnetic confinement. In a tube of reasonable dimensions these currents must continue for at least one-tenth of a second. Such current amplitudes clearly present difficult technological problems. I think, that the papers presented at this conference, and the discussions which follow show that it is still impossible to answer the question—Can electrical power be generated using the light elements as fuel by themselves? I believe that this question will be answered in the

next decade. If the answer is yes, a further ten years will be required to answer the next question—Is such a power source economically valuable ?

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Fuel Efficiency Exhibition

No. II—(*Concluded from page* 534, *October* 3)

WE conclude here our account of the Industrial Fuel Efficiency Exhibition, which has been held at Olympia, London, and closed on Friday, October 3, with descriptions of certain items of ancillary fittings and equipment. British Boiler Accessories, Ltd., exhibited a "Helitube" heat exchanger which is of compact serviceable design and suitable for a wide range of industrial applications. The unit consists of a jacket which houses a number of small bore tubes closely coiled into a helical shape and with their ends secured to tube plates by a tight fitting ferrule which beds the tube into a grooved seal. This system applies when copper or aluminium and copper tubes are fitted; steel tubes, however, are welded to the end plates. Although the tube plates are fixed rigidly in the jacket, there being no expansion plates or floating head, no stress is put on the end fixings because the light springing action of the tube absorbs vibration and high variations in temperature. Liquid passing through the tube is in close contact with heat transfer surface and the liquid in the jacket flows nearly at right angles to the coils thus ensuring the maximum coverage of the transfer surface. Standard working pressures are 120 lb per square inch both on the tube side and in the shell and units are available having heating surfaces ranging from 2·6 to 176 square feet in small increments and then to 616 square feet in larger amounts.

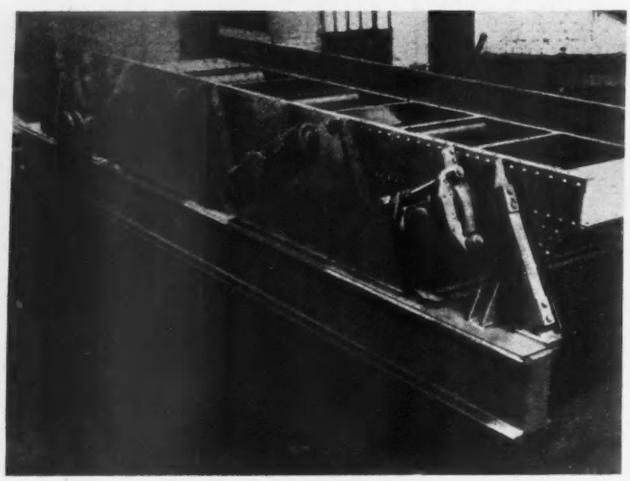


Fig. 4—Extra heavy duty Flamrich "Cleartop" screen—West's (Manchester), Ltd.

On the stand occupied by West's group of companies the display illustrated activities related to the fuel industries and to fuel efficiency including gasification of low grade coals, production of smokeless fuels, gas and coke, coal preparation, and structural work. West's (Manchester), Ltd., had as its main exhibit a large Flämrich "Cleartop" screen and "Wemco" coal preparation equipment. The 6ft by 15ft "Cleartop" extra heavy duty run-of-mine screen shown in Fig. 4 has been developed to deal with the largest feed sizes and is now available to the British coal industry. It has been designed to meet the severe operating conditions obtaining when material is received direct from the mine; there is an absence of obstructions above the screen surface so that flow of even the largest lumps is not impeded. The screen, which operates on relatively shallow slopes, has a long stroke to avoid pegging shale in openings up to 8in and a high weight ratio between balancing frame and screen frame ensures that operation is continuous under heavy overloads. Power requirements are low and there is little vibration in the supporting structure while capacities range up to 500 tons per hour for coal and 180 tons per hour for coke and the stroke is adjustable up to 1¼in with speeds of approximately 600 r.p.m.

A working model demonstrated the "Wemco" dense medium separation plant, which employs magnetite as the dense medium with magnetic recovery, while a laboratory unit demonstrated the "Wemco" froth flotation process for cleaning coal slurries. It incorporates the "Wemco" rotor-stator principle to achieve air dispersion in the pulp and high tonnage capacity per cubic foot of cell volume.

Many examples of oil firing equipment were shown, and White's of Hebburn (Engineers), Ltd., exhibited a new "Spinfire" rotary cup oil burner, as shown in Fig. 5, which is manufactured under licence from Saacke K.G. of Bremen. It is suitable for firing boilers having evaporation rates of from 1000 lb up to 60,000 lb per hour and the nine models available have maximum oil flows ranging from 90 lb to 3300 lb per hour. A large range of modulation is available with turn down ratios of 4 to 1 for the smaller units and 8 to 1 for the larger, with the control being either fully automatic or by single lever and giving the correct air/fuel ratio. An electric motor mounted on the backbone of the burner drives the primary air fan and the rotary cup through vee belts and the fuel, which may be up to 6000 seconds viscosity, is fed into the cup through

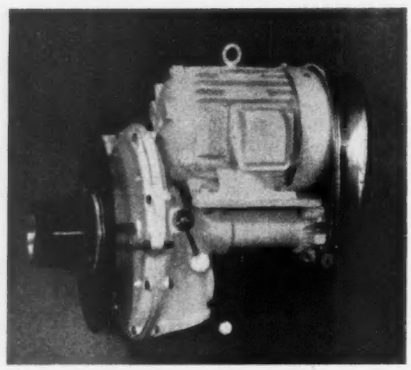


Fig. 5—White "Spinfire" rotary cup burner

radial holes in the front bearing housing, thus avoiding sealing problems. The oil is discharged over the edge of the cup in a thin film which is broken up by the swirling primary air which forms about 7 per cent of the total combustion air. Adjustable air swirl vanes are incorporated in the secondary air register, across which the pressure drop is about 2in to 4in water gauge.

John I. Thornycroft and Co., Ltd., besides showing an oil burner having an output range of from 150 lb to 2000 lb per hour, and a spring-loaded master pressure control valve, capable of passing up to 14,500 lb of oil per hour at pressures up to 500 lb per square inch, included an oil fuel pumping and heating unit of Simplex pattern. This unit, seen in Fig. 6 has been designed for use with high temperature hot water boilers; it incorporates a coil of finned tube as a heat transfer medium and is so arranged that a temperature gradient is maintained between the oil and the hot water. A Plenty variable output oil fuel pump is incorporated and the unit operates at a maximum oil pressure of 450 lb per square inch and an output up to 4100 lb per hour.

Examples of the various burners manufactured by the company were shown by the Thermic Equipment and Engineering Company, Ltd. They included: an eddy flame oil burner, medium pressure "Y" burners used for conversion from gas to oil firing or where low consumptions are required, and combination gas/oil burners which are employed for heat treatment furnaces and where the flame is completely sealed in the furnace and the combustion air controlled by metering valves. The John Zink D.A.18 burner is a multi-purpose unit suitable for either vertical or horizontal firing with either long, narrow, short or bushy flame conditions and covers a capacity range of between 1,000,000 to 23,000,000 B.Th.U. per hour. Thermal high velocity oil burners were also shown, having capacities from 100,000 to 12,000,000 B.Th.U. per hour and in which the combustion of the fuel is completed within the burner block. The hot products of combustion are emitted as a short non-luminous flame up to 12in long and having a velocity of between 200ft and 500ft per second.

Oil-burning equipment to meet up-to-date requirements was displayed by the Wallsend Slipway and Engineering Company, Ltd. It included low air pressure regulated swirl burners arranged for high/low control, one burning 60 lb per hour with natural draught, and another 160 lb per hour with forced draught and having single lever control with a 3 to 1 turn down. A fully automatic pneumatically-operated remote control burner was shown which was developed for power stations and has pneumatic insertion and retraction of burner and

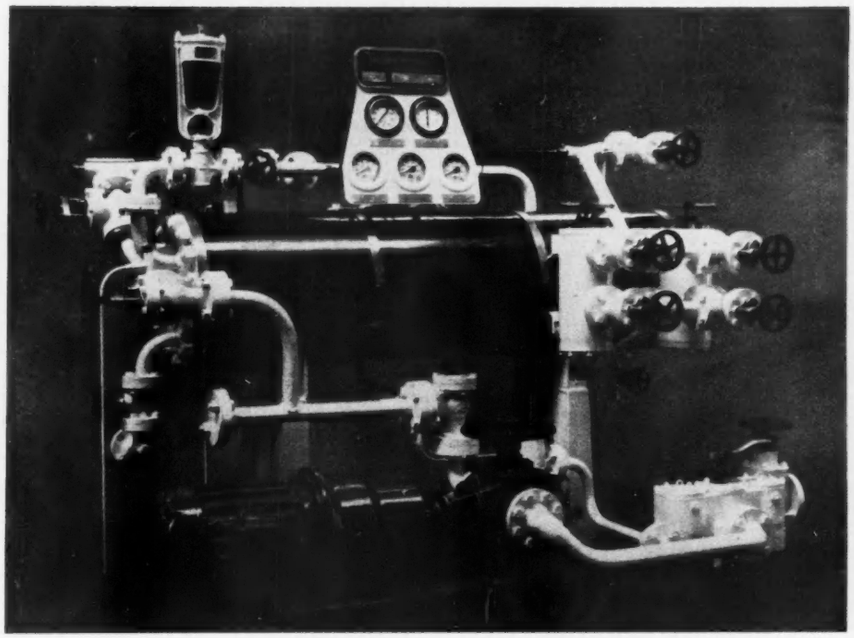


Fig. 6—Oil fuel pumping and heating unit—Thornycroft

torch, and a fixed output of 1000 lb per hour. There was also a self-proportioning automatic burner, with a 5 to 1 turn down, which is mainly for furnace application and burns 3500 seconds fuel.

One of the exhibits on the stand of Joshua Bigwood and Son, Ltd., was the company's recently developed underfeed coke stoker firing a Beeston "Major" boiler rated at 792,000 B.Th.U. per hour. The sheet steel hopper has a base manufactured in vitreous enamelled steel plate as are the transfer trough and the feed screw housing. An enclosed worm reduction gear, with pawl and ratchet mechanism to provide a variable number of rates, drives the feed screw while the primary movement of coke from the hopper is by a ram supported on a chilled iron plate. The multivane fan has a steel impeller running in a cast aluminium casing. The feed screw is of chrome molybdenum cast steel with an end of special grade chilled iron and the feed trough is of abrasion resisting chilled iron constructed in sections for easy removal. Close grained heat resisting cast iron is used for the retort which has ample air passages and a central burner pot surmounted by tuyeres and corner blocks proportioned so as to ensure effective cooling by primary air. A device prevents smoking back through the feed trough.

A steam trap, small in size and weight, working on a thermodynamic principle and known as the Spirax T.D., was introduced by Spirax Sarco, Ltd. This strainer unit, illustrated in Fig. 7, is made of stainless steel and consists of: the body, a cap, a flat disc and an inbuilt strainer of which the flat disc is the only moving part. The trap functions in any position and operates up to 550 deg. Fah. and at pressures from 10 lb to 350 lb per square inch without any adjustment. Condensate is discharged when present, the maximum discharge capacity ranging from 250 lb per hour at 10 lb per square inch to 1750 lb per hour at 350 lb per square inch. Superheat, water hammer, vibration, corrosive condensate or freezing do not affect the trap which will discharge reasonable quantities of air and shuts on no load.

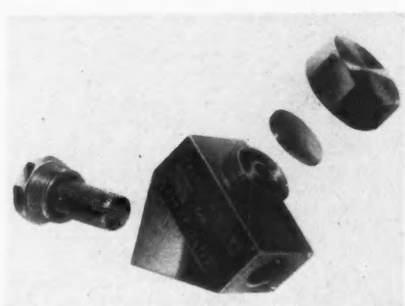


Fig. 7—"Spirax TD" ½in thermodynamic steam trap

British Arca Regulators, Ltd., of which the parent company is Belliss and Morcom, Ltd., showed the Arca A.530 controller which has been developed by the company's French associates and has completed field trials with several industries in France. This is an electro-pneumatic controller employing a combination of electrical and pneumatic principles; it has been designed to operate under the arduous conditions found in steel, chemical and gas works and paper mills. Of simple design, it requires little maintenance and consists essentially of three units, namely, a receiver and amplifier to operate in conjunction with a particular electrical input and to provide an amplified standard deviation signal for the next unit; an electro-pneumatic convertor which converts the output signal from the first unit into a variable air pressure; and a stabilising unit which is a combined electro-pneumatic unit permitting feed back of the output air pressure, into the receiver and amplifier, to obtain the required stabilisation mode. Normal application of the controller is control of temperature up to 1000 deg. Fah. and of pressure control up to 1000 lb per square inch with low pressure control down to ±5mm water gauge. It also controls vacuum, differential pressure, level and speed.

The exhibit of Keith Blackman, Ltd., stressed the efficient use of air and other gases for industrial purposes, and included a 50in Mark AR double-inlet, aerofoil-section, backward-bladed, centrifugal fan impeller, shaft mounted, and an induced draught fan with air-cooled bearings. Also shown was a fan, combining the functions of induced draught and grit arrester, and a bifurcated fan for the recirculation of high-temperature gases. A particularly interesting model demonstrated the Broman Ekström system of shot cleaning for heat exchanger surfaces. This system uses a cascade of shot which strikes the heating surfaces and loosens the deposits. Spreaders distribute the shot evenly over the cross-sectional area of the heat exchanger and in falling it ricochets from tube to tube. Every second between fifteen and twenty-five shots are dropped on each square foot of heating surface and after cascading down the shot is collected and returned to the spreaders by means of a pneumatic system.

A Mark IV furnace baffle for shell boilers, a flue dust blower system for Lancashire boilers, and a Mark II Cory grit arrester were shown by Combustion Equipment, Ltd. The arrester collects over 90 per cent of the particle range classed as grit by the Beaver report—that is, particles of 76 microns and over. It is primarily intended to be fitted to the top of the chimney, but variants are available, the by-pass unit being suitable for installation alongside the chimney base, and the base unit, which can form an integral part of the steel chimney at or near the base. The collected grit particles fall through two pipes to hoppers, from which they can be drawn off periodically, and the draught loss imposed by the arrester is approximately 0·1in to 0·2in water gauge. In operation the blades of the spinner cause the gases to spin, resulting in the solid particles being flung outwards and caught by the deflector, while the cleaned gas escapes to atmosphere. In the collecting chamber the gas conditions are static so that fine particles might bounce outwards; this, however, is prevented by the recirculation annulus. The velocity of the gas across the annulus causes the withdrawal of some gas from the collecting chamber, and a consequent inflow of gas beneath the collector ring. This gas circulation entrains dust and grit and these agglomerate and fall into the collecting chamber.

A catalytic sulphur removal plant able to treat 1000 cubic feet per hour of gas, is shown in Fig. 8; it was one of the exhibits shown by W. C. Holmes and Co., Ltd. This plant will remove 70 to 80 per cent of the organic sulphur, of which there may be as much as 35 grains per 100 cubic feet of town's

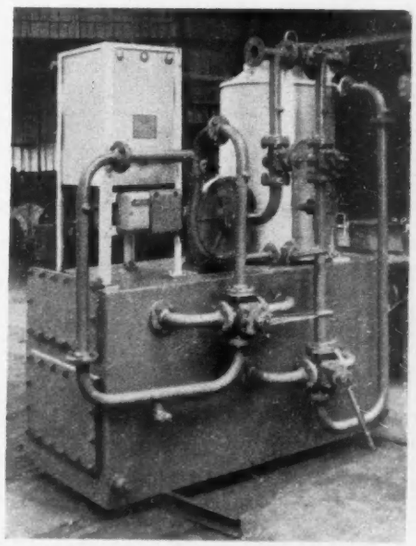


Fig. 8—Catalytic sulphur removal plant—W. C. Holmes and Co., Ltd.

gas, and so make the gas suitable for most purposes. In the process the gas is heated to 300 deg. Cent. and passed through a bed of catalyst where the temperature is raised to 365 deg. Cent. The hydrogen in the fuel gas reacts with the organic sulphur compounds producing carbon, which deposits on the catalyst, and hydrogen sulphide. After cooling the gas passes through a purifier containing iron oxide and the hydrogen sulphide is removed. The catalyst can be regenerated and the iron oxide revivified, while the process, which is operated normally at atmospheric pressure, can operate at pressures up to 200 lb per square inch.

A model of the Holmes-Schneible multi-wash system, was on view. The collector has an efficiency of about 99 per cent for particles above 3 to 4 microns, and consists of a multi-wash collector, fractionating or compensating exhaust hoods, "velocitraps" for removing heavier particles and various dewatering tanks. Other dust collectors were the Holmes-Rothemuhle multi-cell cyclone and the Trion electronic air filter.

The display on the stand of Black Automatic Controls, Ltd., included a number of gas valves among which was a solenoid-operated gas valve specially developed for mounting in a vertical pipeline. In the range of oil fuel valves there was a new solenoid operated lever valve designed for use with high-viscosity oils and embodying a plunger and seat assembled in a reversible cage. This enables the valve to be used either energised to open or energised to close. The switches shown ranged from the small pressure cut-off unit up to those designed to operate at 10,000 lb per square inch and included one of differential design incorporating two diaphragms and a lever system allowing operation at small differentials and high pressures.

Walker, Crosweller and Co., Ltd., exhibited several Arkon equipments for remote reading, one series of which is designed to transmit readings over any distance over the telephone, up to fifteen readings being sent simultaneously. An addition to the Arkon range is the portable gas flow recorder, which gives an accurate record of gas flow in mains from 4in diameter and upwards at pressures up to 30 lb per square inch. No gas shut-off is necessary, and the recorder used is a straight pattern pitot tube inserted in the main and replaced, on removal, by a standard 1in gas plug. The headpiece and stand are of cast aluminium alloy, while the body is of brass sheet and the movement is an oil-sealed bell with a stainless steel calibration spring.

A comprehensive range of automatic control equipment for heating and air-conditioning plant was displayed by Teddington Industrial Equipment, Ltd. The "Transmatic" air-conditioning control system uses printed circuitry and a transistor amplifier, so that simplicity, greater stability and smaller size are added to the advantages of electronic control. High-precision sensing elements of low thermal inertia provide the system with fine control of motorised valves damper motors or sequence switching units. The new version of the "Spediflam II" burner watcher uses a photo-resistive cell as a flame detector and makes amplifiers unnecessary. It will withstand higher operating temperatures and is designed to fail safe under all conditions. Designed primarily for central heating boilers, the "Boilerstat" is available for clamping on to the boiler riser or for insertion fitting, and both models use a bimetal element and a sealed mercury tube switch, while setting is by an external coin-slot adjuster. Also shown was the "W.U." solenoid valve, which is of balanced slide pattern and is for controlling the flow of fuel oil of viscosity ranging from 200 to 1000 seconds Redwood No. 1, at pressures up to 300 lb per square inch. The design includes a built-in adjustable by-pass and a mechanically operated three-contact switch for interlocking valve operation with the burner programme circuit. For the control of flue draught or the pressure in the combustion chamber of shell boilers there was shown a pressure regulator of proportional pattern, which is operated by a diaphragm of synthetic rubber and is sensitive to minute pressure changes.

One of the exhibits shown by Kelvin and Hughes (Industrial), Ltd., was equipment for automatic boiler control which has been designed for low-pressure steam and high-pressure hot water shell boilers. The all-electric system is intended to ensure that the

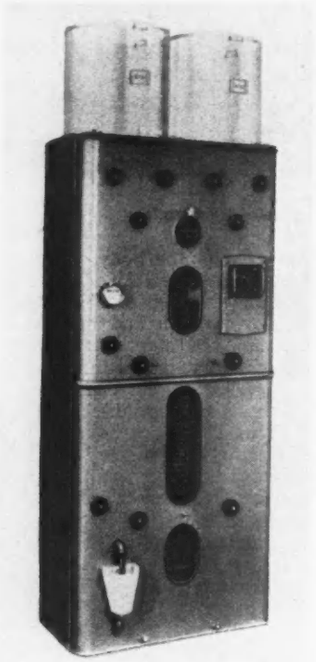


Fig. 9—The Paterson "Solobed" deionisation unit

boiler operates at maximum efficiency under conditions of considerable load variations. Steam pressure or hot water temperature control and combustion regulation are incorporated and equipment includes CO_2, temperature and smoke recorders, loss meters and a multi-point temperature indicator, also a master pressure controller and a steam/flow pressure recorder. There was also displayed a steam pressure control system for oil-fired boilers incorporating a photo-transistor control circuit.

A selection of fuel efficiency instruments manufactured by the Cambridge Instrument Company, Ltd., was on view and a full-size model of a boiler instrument panel demonstrated the control of oil-fired or other boilers for space heating. Among the instruments shown was a magnetic oxygen analyser for the analysis of flue gases, which, since it has no absorbents or catalysts to be renewed, is simple to maintain. There was also a new vertical scale indicator, which is available for temperatures up to 1000 deg. Fah., for draught measurements up to 60in water gauge and for pressures up to 2500 lb per square inch.

The Paterson Engineering Company, Ltd., exhibited equipment for dealing with water supply problems. For the treatment of cooling water by the addition of a sterilising agent, such as chlorine, the company showed an example of the Paterson "Chloronome," built largely of corrosion-resisting plastics and alloys. This chlorinator operates on the vacuum principle and the chlorine gas is held at less than atmospheric pressure from the time it reaches the instrument until it is formed into an aqueous solution at the injector. There is a direct reading flow meter, and the meters, which have a 10 to 1 ratio, cover a range from 0·125 lb to 40 lb of chlorine per hour. Automatic stopping, starting and proportional dosing can be incorporated in the instrument. An alternative instrument shown was the Paterson "Clorocel," which generates chlorine in the form of electrolytic sodium hypochlorite when fed with a solution of common salt or sea-water.

For the softening of hard water there is the Paterson "Accelator," which ensures the rapid completion of the softening reactions and provides for the periodic withdrawal of the precipitated sludge. More exacting treatment is required for the feed water for high-pressure boilers and for this there is the Paterson "Solobed" deionisation plant, seen in Fig. 9, which produces the equivalent of multi-distilled water without the use of heat. The active agents are two synthetic resins, one for the removal of the metals calcium, magnesium, sodium and iron, and giving hydrogen in exchange, while the other removes the radicles carbonate, sulphate, chloride, nitrate, and silicate, and gives hydroxyl ions in exchange. The resins are regenerated by passing dilute acid through one and dilute acid through the other.

Technical Meetings

During the period of the exhibition technical meetings were held, the general theme of which was "Lower Costs and Higher Production Through Better Fuel Utilisation." On Thursday, September 25, under the chairmanship of Mr. J. N. Waite, three papers were read, namely, "Britain's Fuel and Energy Needs: The Next Ten to Twenty Years," by A. Parker, D.Sc.; "The Role of Nuclear Power in the Next Decade," by P. J. Searby, M.A., and J. Grieve Smith, B.A., and "The Coal Outlook and the Problem of Small Coal," by A. Alan Taylor, M.Sc., Ph.D. Four papers relating to the economic application of fuels were presented on Friday, September 26, when the chairman was Mr. S. P. Chambers; they were: "Modern Methods of Coal Preparation as They Affect the Smaller User," by J. T. B. Bookey and Lester Horne; "The Economic Use of Fuel Oil in Industry," by G. F. J. Murray, B.Sc.; "The Economic Use of Gas in Industry," by R. F. Hayman, B.Sc.; and "Economic Applications of Electricity: The Electrifying Revolution," by L. Landon Goodman, B.Sc. Boiler plant and appliances and the Clean Air Act was the subject matter of the three papers given on Tuesday, September 30, with Dr. D. T. A. Townend in the chair. The papers were: "Operating Characteristics of Boilers in Relation to Steam Demand," by E. G. Ritchie, D.Sc.; "Instruments and Automatic Controls in Fuel Efficiency," by W. R. L. Kent, B.A. (Eng.); and "The Clean Air Act: Requirements and Application," by C. M. Opie. Sir John Hacking was in the chair at the concluding session, held on Wednesday, October 1, when two papers were read on fuel and steam utilisation; they were "Planned Maintenance," by J. C. Veale, M.Eng., and "Work of the National Industrial Fuel Efficiency Service," by L. Clegg.

A Pioneer Engineer

GLIMPSES OF WILLIAM BRUNTON AS REVEALED BY HIS CORRESPONDENCE

By T. R. HARRIS

DURING the early nineteenth century a number of distinguished engineers bore the name of Brunton. Of these the best known to modern engineers is probably John. This is because of the publication some time ago of *John Brunton's Book*, the autobiography of this outstanding engineer. John's father, was William Brunton, of the Eagle Foundry, Birmingham. He was one of the pioneer mechanical engineers of this country. Glimpses of some aspects of his career can be caught from a number of letters written by him at various periods to his friend Henry Harvey, of Hayle Foundry, Cornwall.

Readers of John Brunton's book will recall that Henry Harvey took John into his works as an apprentice because of the help William Brunton had given in a lawsuit over the ownership of some quays adjoining Harvey's works.

The following glimpses are possible because the letters from which the information has been culled have lain aside forgotten for well over a century.

In August, 1829, a request had been sent to Brunton, at his London office, 85, Lombard Street, to come to Cornwall to give evidence at the trial on the following Monday. To comply meant certain difficulties for him as he had just returned from South Wales, but he wrote that he had succeeded in making the necessary arrangements and intended " leaving by the mail, tomorrow Friday."[1]

During December, 1829, Brunton was at Bristol " on the Bath and Bristol Railway," and replied to a number of questions sent him by Harvey. These concerned the capabilities of a certain moulder who had applied to Harvey for employment and who had previously worked for Brunton, and the best place to obtain certain materials. To the latter Brunton replied : " The sheet iron is best had from Staffordshire and may be bought very cheaply at present."[2]

Perhaps William Brunton is best remembered for his calciners, fully described by John Taylor, in *Records of Mining*, 1829. By 1830, these were being introduced into Cornwall and in March of that year George Jenkin, Brunton's bricklayer, was sent into the county to erect one at Wheal Vor. In the letter he brought with him to Harvey it was said " You will be pleased to learn that those I have put up at the Birmingham Works and Messrs. Grenfells are doing well and I trust will be the beginning of a general adoption of the plan in which I long to find you something to do. If you will please to let George Jenkin see the drawings of the Calciner castings it will be useful to him."[3]

A scheme for bridging the Avon was on foot in 1830 and Brunton wrote from London " a large quantity of wrought iron work will be wanted for the suspension bridge at Bristol, which I think quite in your way, the following sketches may serve to give you an idea of the kind of work—the holes to be all bored to one size and to the same distance between *very accurately*. The whole weight of these and such like articles will be about 5 or 600 tons. Will you please give the subject your consideration and write to me at the Eagle Foundry, Birmingham by Monday the 15th (that is to meet me there then) stating the price you would deliver the work at Bristol. Taking notice that all the wrought iron will be subject to a proof of $8\frac{1}{4}$ Tons to the square inch. Also state in what time you could engage to execute such an order. You will see the importance of the long and short links being very accurate to their respective lengths and being bored quite square through and also to the same size. The pins are not required to be turned but neatly and accurately swaged the nuts would be of cast iron, for screwing them and also the pins you are already well provided by the pipe screwing lathe. I shall endeavour to obtain for you the order which would give me very great pleasure."[4]

Apparently Harvey was not anxious to commit himself to a large order of this nature and so pencilled a note on the letter " 100 tons in 12 months is as much as we would like to engage to do, 16/6 per ton."

It is interesting to recall, however, that Harvey's neighbours, the Copperhouse Foundry Company of Messrs. Sandys, Carne and Vivian secured the contract and also that for the Hungerford suspension bridge.

Reverting to calciners, the same letter concludes : " I was very glad to learn that the Wh. Vor Adventurers have determined to have another calciner, what diameter have they resolved upon ? My love to John. Mrs. Brunton is much as when I wrote last week. . . . I hope to be in Wales next week."[4]

The difficulty in getting suitable sawyers to saw the baulks of Norwegian timber required for the Cornish mines prompted Harvey to inquire if his friend could oblige him with the drawing of a saw mill for the purpose. Ever ready to oblige Brunton wrote from Morriston, near Swansea : " As soon as I get home which I hope to do next week you shall have drawings for a saw mill."[5]

In July, 1831, Brunton acknowledges a letter from Harvey and also states : " I have received John's letter. . . . I am aware that in a few weeks the two years will have expired in which you so kindly permitted my son to be with you. I feel myself quite unable to express the gratitude I feel for all the kindnesses he has received whilst at Hayle. . . . I hope John has behaved himself with propriety and been diligent at his work. . . . I have been applied to by Mr. Taylor's son, Richard, at the Consols, to know the cost of a calciner like that at Wh. Vor. Will you please inform me at what you will furnish the castings and I will reply immediately. Have the Wh. Vor Company erected the second one yet ? . . ."[6]

Harvey answered the above on July 26 and Brunton acknowledged it on August 19, when he also wrote : " . . . and by this parcel I have written to John and enclosed an order for him to get some money from Wheal Vor to liquidate his debts and bring him home, but I do not limit the time of his return, for if he can render you any service by remaining a few weeks longer I think he will feel gratified in doing so, and I shall have much pleasure also. Besides, I have some expectation of having another large job in South Wales, where John would be useful to me and where he could easily get."[7]

Brunton had been approached by the Consolidated Mines for a water measurer but they restricted him to a low figure in the price. He consequently devoted some time to designing an apparatus of which a drawing was sent to Harvey in August, 1831. In the covering letter, Brunton refers to it as " a patent meter for water," the price of which should not exceed £30 to £32. It was intended " to be applied for measuring the water introduced into the boilers by the feed pump and the cylinder is of such diameter and stroke as to discharge 1 cubic foot every two strokes." Harvey was asked to examine the drawing and state if he could furnish it for the sum quoted. Brunton expressed himself " anxious to introduce one with the hope that they would be found useful and satisfactory so that many might be wanted and thereby become useful to me as patentee and to you as manufacturer."[8]

Later Brunton wrote that he had prospects of introducing the water meter very extensively amongst the water works of London, having received inquiries for " 12 of $15^{3}/_{10}$ dia. of cylinder, 12 of $10^{8}/_{10}$, and 12 of $7^{7}/_{10}$, all of 12" stroke."[9]

Twelve months later, writing from 3, Charlotte Row, Mansion House, Brunton states : " Enclosed you have a tracing of a small engine for an incline plane I am now forming in Breconshire. You will perceive it is to have two cylinders of 11 inches diameter, each to be attached to two cranks at right angles to each other (like a marine engine) without beams. I have recommended that you make it and the party for whom it is desires me to get your price for it delivered at Swansea. I shall be glad if I can procure the order for you. I am going down to South Wales to-morrow and will thank you to write to me as soon as convenient, addressed to me at Mr. Crane's Yniscednyn Iron Works near Swansea. I intend to be at Tavistock in a few weeks and am likely to go into your county, which, if I do, I hope to have the pleasure of seeing you all well. John has always a grateful remembrance of Hayle and desires to present his respects."[10]

REFERENCES

[1] Letter, August 13, 1829.
[2] Letter, December 14, 1829.
[3] Letter, March 29, 1830.
[4] Letter, December 9, 1830.
[5] Letter, December 16, 1830.
[6] Letter, July 22, 1831.
[7] Letter, August 19, 1831.
[8] Letter, August 19, 1831.
[9] Letter, August 26, 1831.
[10] Letter, August, 1832.

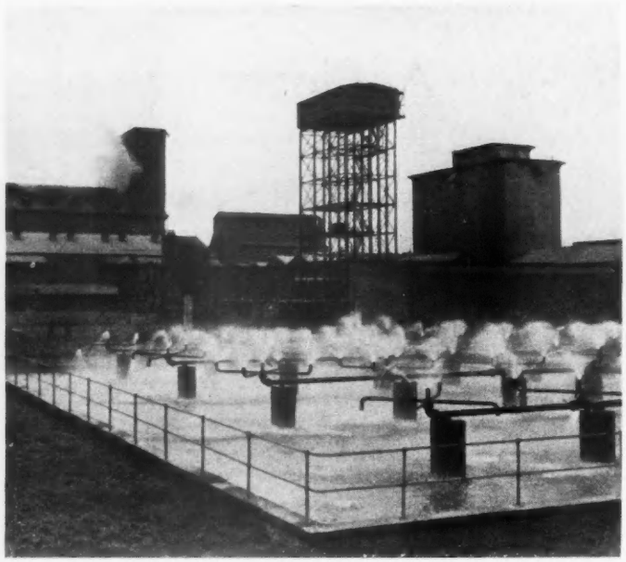
Technical Reports

Methods for Determining the Wave Drag of Non-Lifting Wing-Body Combinations. By L. M. Sheppard. Reports and Memoranda No. 3077. H.M. Stationery Office. Price 10s.—The area rule, moment-of-area rule and transfer rule methods for estimating the wave drag of wing-body combinations are discussed. It is pointed out that the moment-of-area rule and the transfer rule are different forms of the area rule, and that the transfer rule expresses the interference wave drag in a simple form. The existing methods of wave-drag estimation are restricted to combinations with bodies having continuous surface slope, and an extension to combinations with bodies having discontinuous surface slope is given. This paper is concerned with the theoretical methods and their associated numerical techniques, and no numerical results or particular applications are presented.

The Geometry of Wing Surfaces Generated by Straight Lines and with a High Rate of Thickness Taper at the Root. By D. Peckham, B.Sc. A.R.C. Current Paper No. 383. H.M. Stationery Office. Price 3s.—This note describes a way in which wings can be designed to have a high rate of thickness taper at the root, while still maintaining a surface shape generated by straight lines.

The method can be most successfully applied to wings of parabolic arc section straight-tapered in planform, in which case there is no change in aerofoil section shape across the span. Other planform shapes, and wing root aerofoil section shapes, result in a variation of aerofoil section shape across the span.

Power Factor Correction for Calcium Carbide Furnaces



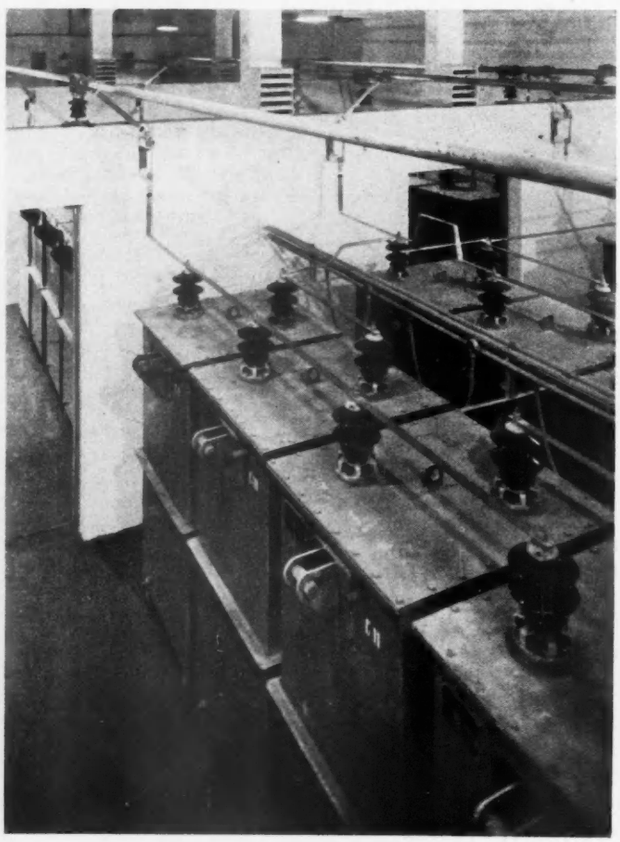
The calcium carbide factory at Kenfig Hill, Margam, South Wales, illustrated here, has been equipped with an 18,000kVAr bank of capacitors for power factor correction. The factory load of 55MW is accounted for mainly by three open arc furnaces with a peak loading of about 17½MW each. Since this installation of B.I.C.C. capacitors was commissioned seven months ago the average power factor has been raised from about 0·85 to 0·96.

AN 18,000kVAr bank of capacitors has been installed for improving the power factor of a works which manufactures calcium carbide at Kenfig Hill, Margam, South Wales. This works forms part of the chemical division of The Distillers Company, Ltd., and has been making carbide since 1940.

The need for power factor correction in this factory springs from the manufacturing process which involves the smelting of lime and coke in an open arc furnace. Briefly, the raw materials required for an output of 1 ton of calcium carbide are roughly 1 ton of lime and 0·6 ton of coke. The reaction takes place at temperatures of the order of 2000 deg. Cent. and heat must be supplied to the raw materials at a rate equivalent to about 3500kWh per ton.

There are three carbide furnaces at Kenfig and each is equipped with three 48in diameter electrodes which are fed at a rate of about 1in per hour. Fresh electrode material is provided to compensate for burning away, by building up, above the clamping ring; this is done by welding on lengths of 48in diameter tubular steel sections and filling up with paste. Current is fed to each electrode in the furnace by eight water-cooled brass contact shoes arranged around the periphery, the current being about 10,000A per shoe. The total l.t. current per electrode is 70,000A to 80,000A and the peak load taken by each furnace is 17½MW.

At periods of maximum demand the factory load is about 55MW, of which all but about 3MW is accounted for by the carbide furnaces and the power factor is about 0·85 lagging. Because the South Wales Electricity Board exacts a financial penalty if the average monthly power factor falls below 0·95 lagging it was decided to install equipment to raise the power factor above this value. To effect this improvement a bank of 72 tank-type capacitors with a



The capacitor house at Kenfig contains seventy-two tanked units of 18,000kVAr with provision for extension. These views show the ventilation ducting, overhead busbars, off-load isolators, fire protection system and the conduit system carrying the thermometric circuits from each tank to the control room

rating of 18,000VkAr was supplied by British Insulated Callender's Cables, Ltd., 21, Bloomsbury Street, London, W.C.1. This equipment, which is believed to be the largest installation of shunt connected capacitors on an industrial load in Great Britain, was made in the B.I.C.C. works at Helsby, Lancs.

Electricity is supplied to the Kenfig factory by the South Wales Electricity Board through two 45MVA, 132/33kV transformers feeding duplicate busbars. Connected to the 33kV busbars are three 10·2MVA furnace transformers as well as two 10MVA, 33/11kV transformers for auxiliary supplies to the factory. Each of these auxiliary transformers is protected by a 33kV oil circuit breaker.

Each of the 10·2MVA furnace transformers consists of a bank of three single-phase delta-connected units. On each phase the secondary winding (which supplies one electrode) consists of eight single turn coils in parallel (one for each electrode shoe). The three secondary windings with their electrodes form a closed mesh.

During normal operation the secondary voltage is 157–164V. To cater for all conditions from starting up, the primary windings are provided with tappings giving thirteen steps between 220V and 136V.

Since the carbide furnaces form the major part of the total electrical load, it was decided that the capacitor bank should be connected as near as possible to the furnace transformer primary busbars. It was also decided to divide the 18,000kVAr bank into two equal capacitor sections, one being connected to the secondary side of each 10MVA auxiliary transformer, and to use the 33kV oil circuit breakers to switch each section. These circuit breakers were uprated to 750MVA breaking capacity as an additional precaution. The voltage rise on the secondary side of these transformers resulting from the installation of the capacitors was not expected to cause serious difficulties ; in fact it has been successfully accommodated by adjustment of the off-load tappings on the transformers.

Before the capacitor design was finalised the harmonic content in the supply waveform was investigated, in conjunction with the South Wales Electricity Board. The results indicated that derating of the capacitors was unnecessary. The 10MVA transformers are connected on the secondary side, through 11kV oil circuit breakers, to a ring-main circuit which is provided with a normally open bus-coupler. By closing this bus-coupler it is possible to supply the total auxiliary load from one 10MVA transformer whenever the other transformer, with its associated capacitor bank, is switched out of circuit.

Each 9000kVAr capacitor bank has an oil switch for off-load isolation. This switch has Castell mechanical interlocking with the 33kV and 11kV oil circuit breakers and with the doors of the capacitor building. Electrical interlocking is also provided between the 33kV and 11kV oil circuit breakers controlling the 10MVA transformers. Facilities are provided for the remote operation of the oil circuit breakers from panels in a control room which is manned twenty-four hours per day.

Because of the prevailing atmospheric conditions the capacitors could not be installed conveniently in the open and a brick building was put up to house them. In this building the 9000kVAr banks were installed in two separate rooms. Part of one of these rooms is illustrated here. In each room there are thirty-six 250kVAr 6·35kV, 50 c/s, single-phase oil impregnated tank-type capacitors arranged in three bays with an additional bay in case a fourth furnace should be installed.

The supply for the capacitor banks is brought into the building by underground single-core lead-covered cables, terminating in wall-mounting cable sealing boxes in each room. An overhead system of copper tubular busbars supported on porcelain insulators carries the supply to each bay of capacitor banks. Flat copper strip busbars are used for the connections between the bushing terminals of the capacitor tanks and pole-operated off-load isolating switches which, in turn, are connected to the overhead busbar system. The twelve capacitor tanks in each bay form a three-phase section of the complete bank with facilities for off-load isolation.

Besides the normal internal fuse protection of element groups within each capacitor tank, supplementary protection is provided for each three-phase section of twelve tanks. Each section is divided into two equal star-connected groups with a fully insulated wound primary current transformer connected between the two floating neutral points. A relay in the secondary circuit of the current transformer operates an audible alarm in the control room whenever current flow between the neutral points reaches a pre-selected value. In the event of a major loss of capacitance in the tank, the alarm will operate before serious over-stressing of the remaining sound capacitors results. Indications of bus faults within any section are also ensured.

Because of atmospheric conditions it was necessary to pressurise the plant, and to keep the temperature within the building to permissible limits, a comprehensive ventilating system had to be installed. The total heat loss for the two tanks of capacitors is approximately 45kW which has to be dissipated by the ventilating plant.

Insulation of the roof has been carried out to limit absorption of heat from outside. At the intake end of the system, filters have been installed and two fans are arranged to feed air into the ducting. In cold weather one fan only need be used to keep the inside temperature below the permissible limit. The inlet fans and filters are installed in a separate room at the south-west end of the building, with the inlet grill in this wall. The extract fans are at high level at the north-east end of the building. Visible indication that the fans are running is provided in the control room.

Thermometers installed in the building permit remote indication in the control room of ambient temperature in either of the capacitor rooms. Should the ambient temperature exceed the permissible limit an audible and visual alarm is provided in the control room. Every capacitor tank is fitted with a resistance thermometer connected to a multipoint indicator in the control room.

Carbon dioxide fire-extinguishing equipment has been installed in the building. This system is brought into operation by means of electrical heat detectors located at ceiling level in each room. Audible and visible warnings are given in the control room if the fire extinguishing equipment operates.

The control room houses the metering panels for all the electrical plant. It also contains a multi-point temperature indicating panel and a Watford maximum demand recording panel with alarm indication and with provision for control facilities if required.

With this equipment it is hoped to be able to maintain a monthly load factor of about 98 per cent. An annual saving of about £30,000 on the factory's electricity bill can be envisaged.

The capacitor bank was ordered on June 20, 1957, and the installation has been in operation since its commissioning on March 4, 1958.

The organisations that collaborated in the installation of the power factor connection scheme are : consulting engineers, Engineering Division (South), The Distillers Company, Ltd. ; capacitors, busbars, cables and sealing boxes, British Insulated Callender's Cables, Ltd., and British Insulated Callender's Construction Company, Ltd. ; switchgear and protective gear, The English Electric Company, Ltd. ; temperature indicating equipment, Cambridge Instrument Company, Ltd., and J. H. Hayman (Electrical Engineers), Ltd. ; installation of secondary wiring, J. H. Hayman (Electrical Engineers), Ltd. ; ventilation, Troughton and Young (Heating), Ltd. ; CO_2 fire extinguishing equipment, The Pyrene Company, Ltd.

Power Supply in India, 1956-57

DURING 1957, the total electricity production of public utility undertakings in India was 10,835 million kWh, according to the Central Water and Power Commission, New Delhi. This is 1200 million kWh more than in 1956, and about 2250 million kWh more than in 1955. In 1947, that is, ten years ago, the generation was just over 4000 million kWh ; there has thus been a 2·5-fold increase in the total production in ten years, the installed capacity during this period having gone up from 1363MW to about 3000MW. Of the total production in 1957, 54·5 per cent was generated by steam plants, 43 per cent by hydro plants and the remaining 2·5 per cent by diesel plants.

In 1956, for which more information is available, the total generating capacity at the end of the year was 2886MW consisting of 1596MW of steam plants, 1062MW of hydro plants and 228MW of diesel plants. The generation during the year amounted to 9662 million kWh, about 53 per cent of which was generated by steam plants and 45 per cent by hydro plants. There were 644 individual generating stations in operation of which fifty-three were hydro, ninety-one steam and the remaining 500 diesel. The average size of power stations thus works out at 20,000kW (hydro), 17,600kW (steam), and 450kW (diesel).

Of the total of 2174 sets in service, 1787 were a.c. with a total installed capacity of 2854MW and the remaining d.c. Of the a.c. sets, there were only 110 sets whose capacity was in the range of 10,000kW and above ; these contributed about 65 per cent of the total installed capacity : 1464 sets were of capacity below 1000kW. In terms of generation, 320 undertakings out of a total of 644 contributed 0·8 per cent of the total generation. Thirteen per cent of undertakings (with an annual generation of between 1,000,000kWh and 10,000,000kWh) contributed 8·6 per cent of the total production. There were only nineteen undertakings generating more than 100 million kWh per year and these contributed 88 per cent of the total generation. Three per cent of undertakings thus generated over 88 per cent of the total production while 50 per cent contributed less than 1 per cent.

In addition, certain industries produced power in their own establishments to the tune of 2210 million kWh. Inclusive of this, the generation amounted to about 12,000 million kWh giving a *per capita* output of about 32kWh per year. In 1947, this figure was about 18kWh. Total expenditure up to the end of 1956 amounts to Rs. 390 crores, that is, roughly, Rs. 1350 per kilowatt installed. The average revenue per kilowatt-hour sold for all purposes is estimated at 1·125 annas,* that is, 1·27d

* 1 anna = 1·125d

SHORTER REPORTS

St. Lawrence Telephone Cable Scheme

A SUBMARINE telephone cable system between Newfoundland and the mainland of Canada is to be provided by Submarine Cables, Ltd., Mercury House, Theobalds Road, London, W.C.1. The contract for this project, worth about £900,000, has been placed by the Canadian Overseas Telecommunication Corporation of Montreal. The new system will form part of the proposed submarine telephone link between Great Britain and Canada and will provide 120 telephone circuits ; the main Atlantic cable link will provide sixty telephone circuits in 1961.

Terminal stations for the link between Newfoundland and the mainland will be sited 400 nautical miles apart near Grosses Roche, Quebec, on the south side of the St. Lawrence estuary, and near Corner Brook in the Bay of Islands on the west coast of Newfoundland. At the western end it is planned to link the circuits with the Canadian telephone network by micro-wave radio relay.

A coaxial cable of 0·935in diameter over the insulation will be used for the crossing. The inner conductor will be a 0·260in solid copper rod, and the outer conductor will be six copper tapes, each 0·475in by 0·015in, held in position by a copper binding tape 0·004in thick. Polythene, mixed with small percentages of butyl rubber and antioxidant, will form the insulation. Over the outer conductor, a cotton tape coated with " Telconax " (a mixture of rubber, bitumen and wax) will be applied for protection against corrosion, and will be followed by the conventional jute serving, galvanised steel armour wires and outer serving. Two main kinds of armouring will be used : No. 2 S.W.G. (type E) for shallower water and No. 8 S.W.G. (type B) for depths down to 200 fathoms. For type E the overall diameter is 2·04in with an estimated weight in air of 12·8 tons per nautical mile ; for type B the corresponding figures are 1·65in and 8·05 tons per nautical mile. At the shore ends double armoured cable will be used for protection against ice. The cable and repeaters will be laid by the contractor's 4500-ton cable-ship " Ocean Layer."

Telephone circuits will have 4 kc/s separation, using the frequency bands 60 to 552 kc/s and 672 to 1164 kc/s for both directions of transmission. Cable attenuation at the highest frequency will exceed 1100 dB, and twenty submerged repeaters will be included to compensate this loss. Equipment will be provided on shore at each end for translating the circuits into two supergroups, each of bandwidth 312 to 552 kc/s for retransmission. The completed repeaters are approximately 10½in in diameter and 9ft in length ; in air they weigh half a ton. The repeaters are inserted axially in line with the cable and are paid out with it during laying. Externally the repeater container is cylindrical. The cable enters and leaves at opposite ends through sealed glands mounted in bulkheads and protected by pressure equalising diaphragms. These bulkheads are brazed into position in the last manufacturing operation. The electrical equipment of the repeater is mounted in an inner container which, like the outer housing, is also sealed and filled with inert gas. Each repeater contains two valve amplifiers and each amplifier has three valves, the circuit arrangement being such that the failure of one amplifier would not prejudice repeater performance.

The repeaters are energised in series from power units on shore, by direct current carried (with sea return) along the central conductor which is also carrying the telephone circuits. The current is kept constant within close limits the supply potential being adjusted automatically to compensate for variations due to magnetic storms or other causes. Faulty repeaters can be identified from the shore stations and progressive deterioration of an individual repeater can be observed in terms of the increased noise contributed to the system. The problem of matching the gain of the repeaters to the loss in cable will be simplified by the recent development of a variable equaliser which is sealed into a submersible housing and is adjustable (without breaking the seal) by internal gravity-controlled devices to compensate for small errors of equalisation accumulated over the whole route. These adjustments may be made just before the equaliser is laid.

Conference on Forge Modernisation

A CONFERENCE, arranged by the British Iron and Steel Research Association, on " The Modernisation of Forges," was held recently at Ashorne Hill, near Leamington Spa, under the chairmanship of Mr. F. J. Somers. It was attended by about 100 representatives of more than forty member firms of the Association. There were three papers presented for discussion. The first, entitled " Building a New Forge," was given by Mr. A. C. Lowe, of Thos. Firth and John Brown, Ltd., who spoke about the rebuilding of the 1750-ton press shop at the Atlas Works, Sheffield. He described the factors which had to be taken into account when the question of rebuilding was under consideration and the way in which the new plant was fitted in with the existing facilities.

The second paper, entitled " Features That Make for a Well-Designed Modern Forge," was given by Mr. E. Homer Kendall, of Kendall Contracting Inc., Alliance, Ohio. He stressed the need to allocate separate space to the heating process, the forging process proper, and the laying down of completed jobs and any necessary heat-treatment, so as to ensure the greatest flexibility in operation and unimpeded flow of work. Mr. Kendall discussed the factors which determine the kind of equipment which should be installed in each. The last paper, given by Mr. J. Banbury, of the B.I.S.R.A. Operational Research Department, was entitled " A Method for Comparing Alternative Ways of Forging." Mr. Banbury, referring to work carried out by his department, showed how the method had been used by a company to compare an existing forge with a proposed new forge for the purpose of deciding whether to re-equip. He also described the way in which the same technique could be used for comparing different forges so that cost-and-time-saving factors could be pinpointed.

International Conference on Gearing

THIRTY-NINE papers were presented at the International Conference on Gearing, which was organised by the Institution of Mechanical Engineers and held in London from September 23 to 25 last. The papers were arranged and discussed under seven main headings—gear tooth loading ; tooth forms, stresses and failures ; lubrication ; production of large gearing ; production of medium gearing ; measurement ; and applications. At the end of the conference the president of the Institution, Air Marshal Sir R. Owen Jones, invited Dr. H. E. Merritt, the chairman of the organising committee, to make some concluding remarks summing up the conference.

Dr. Merritt said that the conference had, he believed, covered the whole field of gearing in a fairly logical order, starting with forces which act upon gears, continuing through design considerations, production questions, measurement, and concluding with applications.

It had been suggested to him by a delegate that it would be useful if there could be picked out of the proceedings of the conference one or two specific things which appeared to emerge, The first session dealt with gear tooth loading, primarily with the influence of errors and velocity on dynamic load, and, secondly, with the effects of maldistribution of load lengthwise. When designers dealt with maldistribution, it was probably necessarily a somewhat empirical treatment, but the emphasis that had been laid on dynamic loading would, it was to be hoped, stimulate the application of that kind of study to more design practice than it now takes part in.

The first session included in its formal agenda the question of noise. This received relatively little attention until the discussions on the final day, and it was surprising that a topic which was perhaps one of the most burning of all topics in gearing circles for so many years should have received so relatively little attention during the design and production discussions.

At the second session tooth forms, stresses and failures were dealt with in eight papers of great diversity which it was difficult to condense into a homogeneous form. Included among those papers were two which illustrated the kinds of failure which did occur in gears in service, and they might have some cautionary value against the too easy acceptance of simple rules for designing gears. Perhaps the most important thing which came out of the second session was the growing need for more rigid specifications when issuing drawings for manufacture. The general tendency to leave a great deal to the know-how of the people on the shop floor must give place, in the case of gearing, to the need for much more precise definition and specification of those things which the discussion showed to be vital to the durability of gearing, notably the accuracy of tooth form. The need for the greater control of manufacturing processes and the treatment given to fillet radii came in for special discussion. Another point which came out of the discussions of the second session was that the accuracy with which gears and gear cases need to be designed and manufactured was no longer the yardstick for tolerances—it was no longer what was convenient practice in the shops —and the real yardstick was the unit represented by the deflection of a tooth under load.

At the third session there were four papers dealing with lubrication. The traditional approach to lubrication was—and this was expressed in one of the papers—that for nearly all ordinary purposes a lubricant should be found which would do the job. But although further guidance was given on the every-day choice of lubricants, there was one special feature about the discussion at that session, and it was the incursion of the younger generation of physicists into the discussion. That indicated that fundamental studies into what really took place between two gear teeth separated by an oil film were now being taken seriously. Whether this would greatly affect the choice of lubricants or the lubricants offered remained to be seen, but Dr. Merritt suggested that it would have a much more profound effect not merely on lubricating practice, but on the knowledge that was still needed on the real criteria of surface load-carrying capacity.

In the fifth session, on the production of medium gearing, it had been expected to draw more discussion from those who were concerned with the manufacture of gears of that kind. Nevertheless, the papers offered to the conference were primarily three on the manufacture of spiral bevel gears, or, perhaps, the development of machines for the manufacture of spiral bevel gears. They represented a most interesting exercise to the student of gear geometry. They also illustrated that while gear-cutting machine tools may be designed on strict kinematic principles, the other problems which arose in manufacture still left in gear production that element of art which required that, having acquired a theoretically correct profile, it was departed from! The absence of comment on production problems might mean that the production men were by way of being doers rather than talkers.

The four papers on gear measurement produced discussion that could have continued almost indefinitely. It was difficult to summarise the session, except to say that it was now clear that

production techniques had advanced to the point at which the techniques of measurement were becoming seriously strained. There was scope for much intensive development of measurement methods.

At the seventh session, under the heading of applications, there had been a lively discussion primarily with reference to marine gearing, and there was more discussion at this point than Dr. Merritt expected on criteria for surface loading. This was a subject, obviously, which remained controversial, and his only personal observation was that the problem would be resolved more simply when, instead of the four different methods which had been given in the papers in the conference for expressing the intensity of surface loading, they had one—it did not matter which one, so long as there was one agreed criteria.

Reorganisation of the Admiralty's Material Departments

THE reorganisation of the Material Departments under the Controller of the Navy, announced by the First Lord of the Admiralty in the House of Lords on December 19, 1957, commenced in January of this year, when the Fourth Sea Lord assumed, in addition to his responsibilities for supplies and transport, responsibility on behalf of the Controller in the field of repair and maintenance of the Fleet and was planned to be completed on October 1, with the setting-up of the new Ship Department. The work will then have been reorganised into four large material departments, each headed by a Director-General, and a small group of scientific departments headed by the Chief of the Royal Naval Scientific Service.

The four material departments are : the Ship Department—responsible for the design and production of H.M. ships, their propelling machinery, auxiliary machinery and electrical installations ; the Weapons Department, responsible for the design, production and installation of surface, underwater weapons and weapon systems, radar communication and compass equipment for H.M. ships ; the Aircraft Department, responsible for ensuring that the Admiralty's air material requirements are met and operates satisfactorily in service, and the work has been allocated to two divisions and two independent sections ; the Dockyard and Maintenance Department, responsible for the repair and maintenance of the Fleet and the provision of Marine Services to the Fleet, and the work has been allocated to three divisions.

The Scientific Departments are headed by the Chief of the Royal Naval Scientific Service, who works under the immediate guidance of the Deputy Controller (Research and Development).

The co-ordination and direction of the work will be the main functions of the directors-general. Particular co-ordinating responsibilities fall to the Director-General of the Ship Department, who will be the principal technical adviser to the Board of Admiralty and the final authority on ship design below the Board. This department is being formed by amalgamating the Naval Construction Department, the material sections of Engineer-in-Chief's Department, the Electrical Engineering Department, the Naval Equipment Department and the staff of the Technical Chief Executive in charge of the "Dreadnought" project.

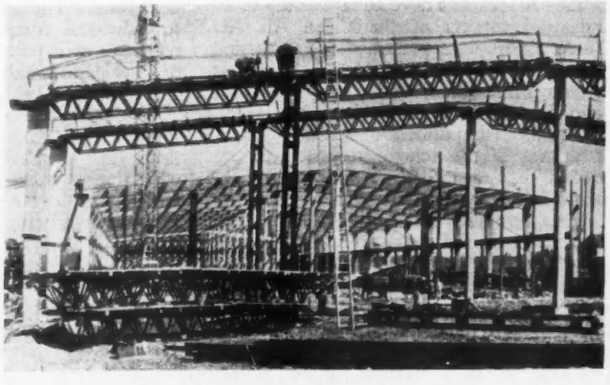
The work of the Ship Department will be allocated to five divisions as follows : the Naval Construction Division—responsible broadly for research, development and design of ships' hulls, hull and general ship equipment, and for the co-ordination of all aspects of the design ; the Marine Engineering Division—responsible broadly for research, development, design and production of propelling, auxiliary and all other steam, hydraulic and internal combustion machinery ; the Electrical Engineering Division—responsible broadly for research, development, design and production of electrical equipment and electrical installations, other than the electrical components of weapon and radio equipment ; the Ship Production Division—responsible broadly for the construction of H.M. ships, the production of hull and general ship equipment and their installation ; the Naval Equipment Division—responsible primarily for advice on the design, layout and installation of ships' fittings and equipments from the point of view of seagoing and fighting efficiency.

The two major features of the new organisation are : responsibility for the construction of H.M. ships will be concentrated in a single division ; design staff engaged on the same or related projects will be located close together. Collectively, they will be known as ship groups, of which four are being created to deal with aircraft carriers, submarines, cruisers and fleet support ships, destroyers and frigates. The ship groups will be supported by six specialist groups whose job it will be to study common technical problems, such as stability, ventilation and lighting.

The Director-General, Ships, will be Mr. A. J. Sims, R.C.N.C. The Directors of the Divisions will be : Mr. J. H. B. Chapman, R.C.N.C. (Naval Construction Division) ; Rear Admiral W. F. B. Lane (Marine Engineering Division) ; Sir Hamish D. MacLaren (Electrical Engineering Division) ; Captain M. L. Hardie R.N. (Naval Equipment Division) ; Mr. H. T. Johnson, R.C.N.C. (Ship Production Division).

Heavy-Duty Centering Girder

A BRACED steel centering beam for use in heavy reinforced concrete construction has been introduced by Rapid Metal Developments, Ltd., 209, Walsall Road, Perry Bar, Birmingham, 22b, and is shown in the accompanying illustration. The "D.S.L. 500" girder, as it is called, consists of intermediate sections, end sections, bearer pins and turnbuckles. The end sections are adjustable in length and by combining the various intermediate sections any span between 9ft 10in and 91ft is possible. The upper booms of the sections are connected by pins and the lower booms by turnbuckles, and by adjustment on the turnbuckles various curvatures are obtainable. Normally, for spans up to 35ft a single course of sections would be used and for spans greater than 35ft a double course. For the heavier loads and spans the standard girder may be stiffened with bracing units. For instance the single "D.S.L. 500" at a 30ft span will carry a total load of 10 tons, we are informed, the double girder at a 49ft span will take a total load of 14½ tons and the braced girder at a 72ft span will take a total load of 25 tons. The firm has also developed a 30-ton folding trestle consisting of various intermediate sections, an adjustable base section and a pyramid or a flat head piece. With various combinations any desired height is possible ; the sections are bolted together and can be folded flat for storage and transit.

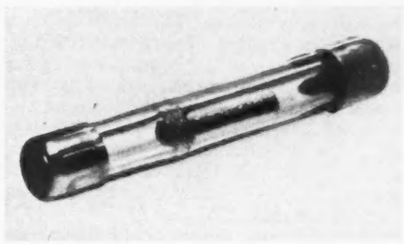


Heavy-duty centering girder

Handy Fuel Filter

A FUEL filter in an unusual and easily applied configuration has now been made available by the Wico-Pacey Sales Corporation, Ltd., Bletchley. This is the Wipac "Filter-Link," a 3in length of transparent plastics pipe of 0·2in bore. Pressed into the pipe is a long hollow cone composed of bronze spheres of roughly 0·01in diameter sintered together. The fuel is forced to pass from outside to inside this cone, removing foreign bodies down to very small sizes ; however, we are assured that water in the oil will pass through and not block the filter.

The element is cleaned by removing the complete assembly and blowing compressed air through it in the reverse direction. The correct direction of flow is marked on the end caps, although these are not irremovable.



Through the transparent walls of the plastic pipe the element can be seen : the direction of flow is right to left

The "Filter-Link" is intended to fit on to metal fuel piping of ¼in o.d. ; if fitted close to the carburetter or engine-mounted pump, it serves the additional purposes of isolating the metal plumbing from high-frequency vibration and of giving a visual check on the supply of fuel. Because of its low initial cost, it may be expected to find application as a secondary filter to safeguard against the risk of dirt being introduced when a conventional filter and water trap is being cleaned.

Institution of Public Health Engineers

THE new president of the Institution of Public Health Engineers, Mr. N. J. Tatman, M.I.C.E., M.I.W.E., M.I.Cons.E., delivered his presidential address at a meeting held on October 1. During the course of his address, Mr. Tatman said that the Institution was to establish a new examination, at an advanced level, for which a diploma would be awarded. The president said that passes in any other examination would not be accepted in exemption, since none were known to cover the entire syllabus of sanitary or public health engineering.

Turning to the present-day position in water supply and sewerage and sewage disposal, the president reviewed several current topics. He thought that the present state of water supply in this country was a cause for national pride. He drew attention, nevertheless, to two specific points where further advance would be desirable : the extraction of water from underground ferruginous deposits was by no means free from trouble, he explained, and it was not possible to be sure of the yield or life of boreholes in such cases. He also thought that soil corrosion of pipelines might be countered by the development of methods based on exact and accepted scientific analysis.

The president then went on to discuss sewage purification. Were we satisfied, he asked, that we knew all there was to be known about the biological agencies at work in the purification of sewage, or even that present methods were incapable of improvement ? Might not systematic research reveal an entirely new method, or even an approach to a new method ? Trial on a reasonable scale of suggested improvements such as in tank design, and in the use of centrifuges, were necessary in his view, and he suggested various other possible or welcome improvements, such as the need for perfecting the mechanical handling of dried sludge.

Industrial and Labour Notes

Employment and Unemployment

The Ministry of Labour says that, during August, there was an increase of 33,000 in the number of people in civil employment in Great Britain. At the end of the month the total was 23,127,000 (15,311,000 men and 7,816,000 women). The principal changes were seasonal ones, the increases occurring mainly in the distributive trades and in professional, financial and miscellaneous services. There were, however, some other changes. In the manufacturing group described as "engineering, metal goods and precision instruments," the employment figure increased by 4000 during August to a total of 2,778,000. There were also more people at work in building and contracting during August, the total for the end of the month being 1,502,000, compared with 1,498,000 at the end of June.

The Ministry's report on unemployment relates to the situation on September 15, when 475,986 people were registered as out of work. That was 30,000 more than a month earlier and represented about 2·2 per cent of the total number of employees. The September figure included 415,926 who were wholly unemployed and 60,060 who were temporarily stopped. The report adds that, in the week ended August 23, about 160,000 operatives in manufacturing establishments with more than ten employees (excluding the shipbuilding and ship-repairing industries) were on short time, losing on the average fourteen hours each. On the other hand, in the same week, there were 1,196,000 production workers who were doing an average of 7½ hours' overtime.

Employment of Chemical Engineers

The Institution of Chemical Engineers has just completed an analysis of the supply and distribution of chemical engineers in Great Britain. The supply and demand position in chemical engineering, the Institution claims, is far from satisfactory; in estimates of future trends in manufacturing and trading, the difficulty of including the chemical engineering manpower factor arises partly from lack of statistical information.

In the preparation of the Institution's analysis, it has been estimated that the total population of qualified chemical engineers in 1956 should have been of the order of 5000 and that this "population" should increase to between 10,000 and 11,000 by 1966. But a recent survey of the annual output of qualified chemical engineers from universities and technical colleges in Great Britain gave the 1956 figure as 277 and the estimate for 1966 as 940. The Institution says, therefore, that if an output of 900 is realised in 1966, the needs of expansion and replacement may be met, though it is unlikely that the present shortage of qualified men will be made good by that time.

Careers in Industrial Design

The Council of Industrial Design has issued a pamphlet outlining the training and qualifications necessary for a career in industrial designing. It emphasises that the designer must be a "member of a team," able to communicate his ideas to clients, manufacturers, fellow designers, sales managers and craftsmen. A good general education, the pamphlet emphasises, is, therefore, an essential starting point.

In a section dealing with product design, the pamphlet says that, before the war, very few light engineering firms employed industrial designers, and consequently the process of both technical and visual designing was carried out by specialist engineers, engineering draughtsmen and directors. The industrial designer, the pamphlet goes on to say, still has to contend with that fact, and although he has made sufficient progress since the war to be accepted as a necessary addition to the design staff, "it will be an uphill struggle for some time before he attains a satisfactory status."

Education in Aircraft Materials

The College of Aeronautics, at Cranfield, has announced the establishment of a department of aircraft materials, which will enable students to take this subject as their main specialisation in the post-graduate college diploma course. The specialisation will include engineering techniques in applications of materials as well as the basic relevant sciences, particularly physical metallurgy and solid state physics. It is stated that research forms an essential part of the new department's activity; several investigations are now in progress, mainly in the fields of creep and fatigue. Students will co-operate in such researches as part of their post-graduate work.

The new department intends to institute a short course on materials, of about two month's duration, which will be open to industry generally. The aim of this course is to present to those concerned with engineering applications of materials a working knowledge of modern developments in materials theory and technology. Those who are interested in an advanced course of this kind are invited to write to Professor A. J. Kennedy, College of Aeronautics, Cranfield, Bletchley, Bucks, so that some assessment of the potential demand may be made.

Industrial Aspects of the Clean Air Act

At the annual conference, last week, of the National Society for Clean Air, one of the sessions was devoted to a study of the industrial aspects of the Clean Air Act. Three papers were presented for discussion. The first of them was by Mr. G. W. Farquharson, Birmingham's chief smoke inspector, who dealt with the control of dark smoke emission. He pointed out that, with the exception of the scheduled processes controlled by the alkali inspectors of the Ministry of Housing and Local Government, the responsibility and duty of ensuring the implementation of the new legislation appertaining to the control of dark smoke emission in England and Wales was placed directly on all local authorities. Mr. Farquharson added that, in his opinion, the full implementation of the legislation by local authorities required constant supervision for contraventions, co-operation with offenders through the strength of enforcement, and the determination of the contraventions through legal proceedings if co-operation failed. He suggested that the control of dark smoke could be achieved if the representatives of local authorities accepted the responsibilities that the full implementation of the Act involved. The common practice of waiting for smoke nuisance complaints from the public before taking action, he remarked, was over; all areas should be subject to constant inspection and contraventions should not be allowed to persist.

The second paper, presented by Mr. T. M. Ashford, was entitled "Grit and Dust Emission: Methods of Practical Control and Regulations." The major part of this paper was devoted to an account of the various methods of dust and grit measurement and control. The final paper was by Mr. N. Bastable on "The Height of Chimneys." Mr. Bastable pointed out that, in power stations and large industrial plants generally, the function of a chimney was solely to secure adequate and satisfactory dispersal of the flue gases. The draught needed for the furnaces could more easily and cheaply be provided by fans. In smaller plants, however, the chimney still played its part as a draught creator and, unless it was well designed, poor burning and smoke emission would result. Mr. Bastable acknowledged, however, that there would be many cases in which a compromise had to be agreed, in designing chimneys, between preserving the amenities of the district and preventing pollution of the atmosphere in the neighbourhood.

Group Apprenticeship

Information as to the progress of the Engineering Industries Association's group apprenticeship scheme was given at a luncheon in London on Tuesday by Mr. D. A. Gunn. He said that the scheme was now well established, with seven groups operating in the London area, four in the Midlands, and one in the North-West, while four new groups were in process of being formed. The number of member firms participating in the scheme, Mr. Gunn added, was approaching 200 and this year's intake would bring the number of apprentices in training to over 300.

It may be recalled that an essential feature of the E.I.A. scheme is the pooling of the training resources of a number of firms in a locality. Any gaps in the training available in a member firm are filled by the transfer of the apprentice for a period to another firm in the group. The apprentices are indentured to individual companies in the group and return to their parent companies in between transfer periods and for their objective training in the last year of apprenticeship. The scheme is controlled in each area by a committee of representatives of the participating firms, the Youth Employment Service and educational bodies. A qualified group engineer arranges the training course and is responsible for the general administration.

Directors' and Executives' Exhibition

The first Directors' and Executives' Exhibition, which is to be held at the Royal Horticultural Society's Old Hall, Westminster, S.W.1, from October 20 to 24, will be officially opened by Sir Miles Thomas, M.I.Mech.E., at 12 noon on Monday, October 20. The exhibition will demonstrate the services available to senior executives, and will include products with a particular "director appeal." Products on display range from advertising novelties to fork-lift trucks, and the "executive services" cover a wide field, including banking, pension schemes, salesmanship courses, floor maintenance, graphic design, and so on.

Production of Sapphire and Diamond Styli for Gramophone Pick-Ups

THE great hardness of sapphire, and the extreme hardness of diamond, have made these two substances the materials of choice for the manufacture of pick-up styli. This is because the great strength and wearing qualities of sapphire and the even better properties of diamond, have made it possible to use much smaller tips compared with those of steel needles, with correspondingly reduced contact force. Such styli will last for a very long time—hundreds of hours in the case of diamond—and thus outlast a steel needle many times over, and will

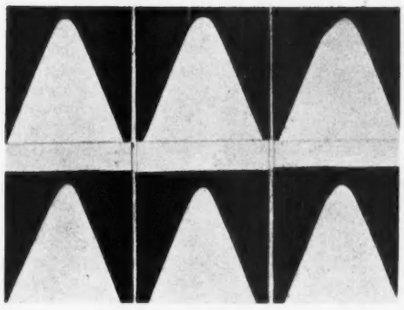


Fig. 1—Sapphire stylus and diamond stylus, both of 25 micron radius, tested under a 12 gramme load against a vinylite microgroove record. Top (left to right) sapphire unused and after 75 and 175 hours. Bottom (left to right) diamond, unused and after 150 and 300 hours

cause less wear of the record than does steel. The smaller moving system of the pick-ups implies lower inertia forces; thus the effective mass at the needle point may be as little as 3 milligrammes, resulting in a cut-off frequency, due to stylus-groove resonance, of the order of 20 kc/s, which is far above the audible frequency range.

The production of the diminutive styli and their assembly under factory conditions are described in a recent article published by the Philips concern.*

Fig. 1 shows microgroove styli of 25μ tip radius which were tested on vinylite records, with vertical loads of 12 grammes. It will be seen that in spite of the considerable pressure on the needle—of the order of 3 tons per square inch—the wear of the diamond point after 300 hours is only just beginning to be noticeable. As the same record was used over and over again in testing each needle, the conditions were much more unfavourable than they are in practice where the particles worn off the point are distributed over many records, thus causing less wear. The superiority of diamond may be seen from the fact that diamond styli may have a useful life over twenty times that of sapphire.

Our second and third illustrations show the initial stages in the manufacture of diamond styli. First a suitable diamond is cut parallel to the octahedral (111) plane and trepanned to give cylinders of 0·3mm diameter and 1·6mm length. For the trépanning, use is made of thin-walled nickel tubes rotating at about 10,000 r.p.m. and charged with diamond dust in oil. The (111) plane is chosen because plates of reasonable area can be cut in this direction, which also exhibit the greatest wear resistance.

Next, a cone is cut at each end of the cylinder. This is done by holding the ends in turn against a cast iron wheel charged with diamond dust in oil, and rotating both the wheel and work spindles at high speed, while giving the grinding wheel a slow reciprocating movement parallel to its surface (Fig. 4). The coning operation is stopped before a perfect point is reached, as this tends to break too easily. The diamond is transferred to a special grinding machine where the end is ground to the required radius with the help of a microscope. When both ends have been radiused in turn, each operation taking about one minute, the diamond is cloven into two halves which after cleaning are ready for mounting.

In the case of sapphire the procedure is similar. Cylinders 3mm long and 0·4mm in diameter are trepanned out of sheets of synthetic sapphire, and subsequently coned at 45 deg. in the same way as described for diamond, except that the grinding is ten times as fast. After the needles have been broken in half, ground to a length of 1mm and cleaned, the radius is put on in the following way. Several thousand needles are placed in a bottle containing diamond dust in oil. The bottle is then vibrated for several

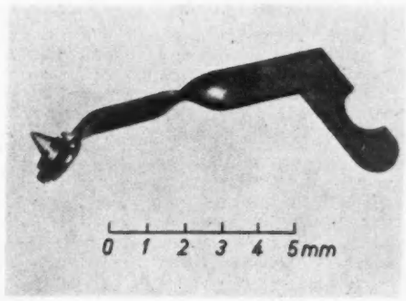


Fig. 5—Finished assembly of stylus and stylus arm

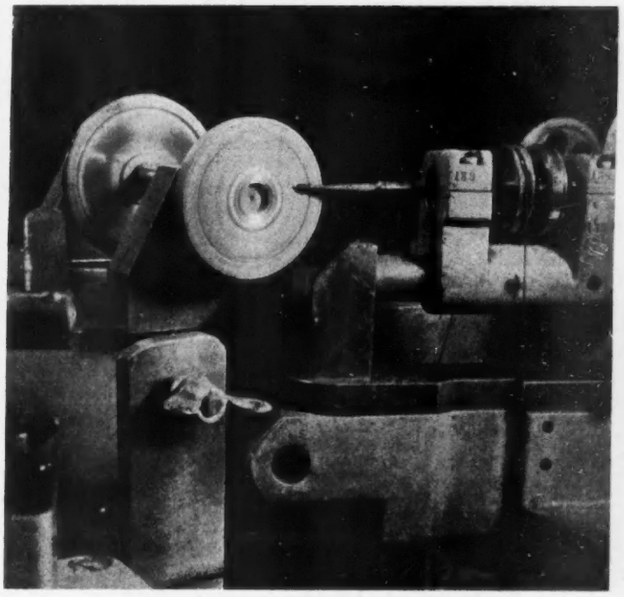


Fig. 4—Grinding machine for coning the ends of crystal styli

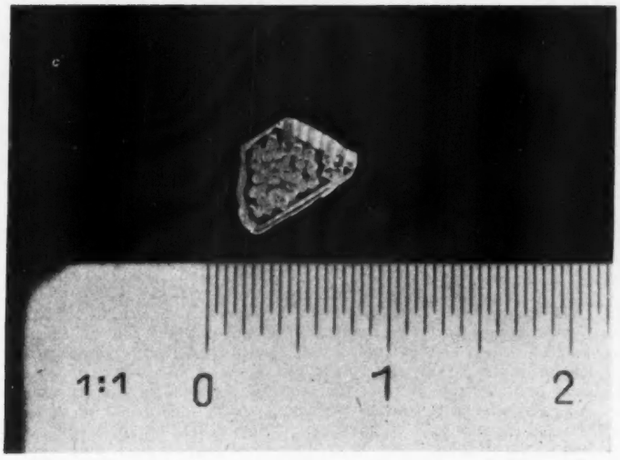


Fig. 2—Diamond platelet, 1·6mm thick, cut along the (111) plane and trepanned to give cylinders of 0·3mm diameter

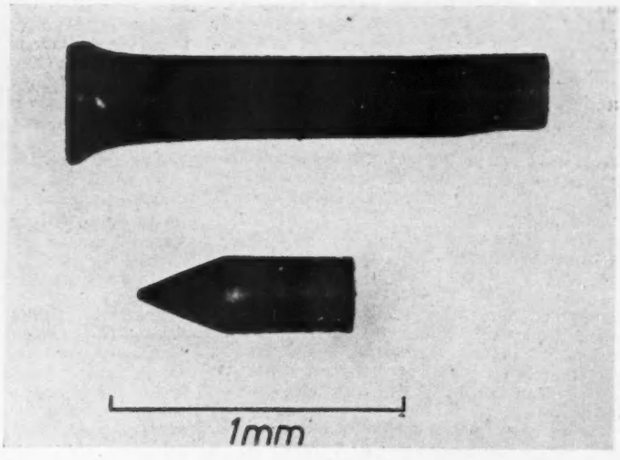
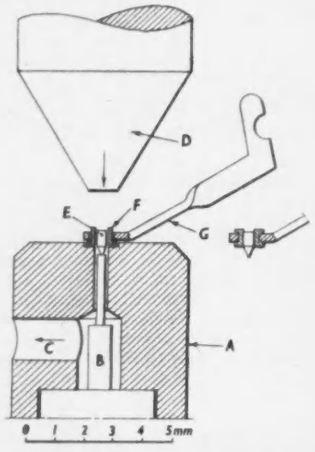


Fig. 3—Shadow photograph of diamond cylinder, as trepanned from platelet, and finished stylus, 0·3mm diameter and 0·6mm long

* A. W. Ploegsma, "Fabrication of Sapphire and Diamond Styli for Gramophone Pick-ups," *Philips Technical Review*, Vol. 19, 1957/58, No. 11, page 324.

days. This causes the ends to become perfectly rounded with the radius gradually increasing with time. The process is stopped at a radius of 25 micron for microgroove records, and 75 micron for standard 78 r.p.m. records.

Finally each stylus must be mounted on an arm as shown in Fig. 5. This operation is carried out in the cleating jig illustrated in Fig. 6. A



A—Hollow anvil. *B*—Spacer.
C—Vacuum connection. *D*—Punch.
E—Stylus. *F*—Bushing.
G—Arms.

Fig. 6—Cleating jig

small aluminium bushing is picked up on the end of a 0·3mm diameter nickel tube through which air is sucked, a method preferable to the use of tweezers, and transferred to the hollow anvil of the jig by means of air suction through the bore of the anvil. A stylus is then inserted point downwards and held by a spacer at the correct distance. After the arm is placed over the bushing, the press is operated, and a rigid connection formed between the stylus and the arm. A projection microscope is used for a final check of the assembly.

Of the original diamond plate less than one-half can be drilled out into cylinders. The remainder is later crushed into powder for the various grinding operations. Diamond dust is also recovered by placing shields on the machines. After cleaning and grading into various sizes by centrifuging, the dust can be used again. The surplus fines are kept for other purposes such as the polishing of metallographic specimens.

Mont Blanc Tunnel

A road tunnel through Mont Blanc linking the Aosta Valley, Italy, with the Chamonix Valley, France, has been under discussion for many years but it is only recently that agreement has been reached between the two countries.* Drilling is scheduled to commence this month from near the Italian holiday resort at Courmayeur, in the Aosta Valley.

The concrete-lined tunnel will be 12km long and will have an overall tunnel area of 73 square metres, requiring the excavation of approximately 1,000,000 cubic metres of rock. The road width will be 7m, with a height of 9m. No precise completion date has been given but the tunnel is expected to be finished in approximately three years.

The cost of the whole tunnel from Aosta to Chamonix, together with the approach roads required in both countries, has been estimated at approximately £5,500,000. In-so-far as Italy is concerned, the major financial participants in the scheme are the Italian Government, the local authorities in Aosta and various Swiss interests. The Società per Azioni per il Traforo del Monte Bianco is sponsoring the 6km long Italian section of the tunnel.

In the face of severe international competition, it has been announced by Atlas Copco that it has been awarded the contract to supply all the compressed air equipment for driving the Italian section of the Mont Blanc tunnel. The contractor for the driving of this section is Società Italiana per Condotte d'Acqua. For the first three months Atlas Copco Italia will provide Swedish drill-masters to train local labour for the tunnelling crews. The equipment consists mainly of AR4 skid-mounted compressors,

Atlas Copco "AR-4" compressor under installation at a hydro-electric project in the Italian Alps. Similar units will be used on the Mont Blanc tunnel. This compressor of 138 h.p. delivers 760 cubic feet per minute at 100 lb per square inch

"Tiger" rock drills and Sandvik "Coromant" drill steels.

The new tunnel, it is stated, will be the largest of its kind in the world. It will be open all the year round and will cater for an expected annual traffic load of 600,000 vehicles, which will include heavy lorries, carrying approximately 1,500,000 passengers. It will contain twenty-four service stations—one approximately every 1000 yards—on both sides of the tunnel, to deal with breakdowns and minor repairs.

The interior of the tunnel will be well illuminated by electric lights throughout, and fine water sprays will reduce the tunnel temperature from around 50 deg. to about 25 deg. Cent. for comfortable driving conditions. In addition to the service stations there will be small recesses every 219 yards (200m), cut out of the rock and large enough to hold a man. No lay-byes will be provided however, and the traffic will proceed in single file in each direction. A speed limit will be imposed, no overtaking will be permitted and a toll will be levied on each vehicle.

By using the new Mont Blanc tunnel the distance from Paris to Milan will be shortened by 313 km (nearly 195 miles).

Formaldehyde Plant

Reichhold Chemie A.G., Hamburg, have announced the recent coming into operation of their new formaldehyde plant which is laid out for an annual production of approximately 5000 tons. The production process is centrally controlled by one service man. Formaldehyde finds application in many industries, particularly in the manufacture of synthetic resins. In addition to formaldehyde, the Hamburg factory also manufactures phthalic anhydride, another important chemical which is primarily used in the production of synthetic resins and plasticisers.

Swedish Textiles

Sweden's textile consumption is likely to rise after the stagnation in the past few years and is estimated to become 25 per cent larger in 1965 than it was in 1955, provided personal incomes continue to increase, according to a survey by the Swedish Industrial Research Institute. Textile prices are expected to rise more slowly than other commodity prices. However, the share of clothing in total purchases is likely to remain unchanged at 12 per cent.

Considerable shifts in consumption among different groups and qualities of textiles are to be expected, the Institute says. The proportion of industrial products will increase and man-made fibres with improved properties will grow in popularity. The consumption of ready-made garments is likely to rise by 40 per cent and knitwear by 25 per cent. Home-made textiles and handicraft products, on the other hand, are expected to show a drop of 10 per cent, while consumption of textiles for interior decoration will rise somewhat faster than the average for overall textile consumption.

Sweden's present textile consumption amounts to close on 11 kg per head of the population. Over the past twenty-five years the consumption of ready-made garments has shown a more than three-fold increase, while the consumption of other textile goods has risen considerably less.

Shortage of Engineers in Switzerland

According to reports in the Swiss press, it would be necessary to train altogether 900 engineers and scientists per year in order to meet the country's needs, whereas the technical universities of Zurich and Lausanne, and the science faculties of Switzerland's seven universities, turn out only some 600 graduates each year, of whom 100 are foreigners who for the most part leave for abroad. The deficiency is thus of the order of 400 per year, and the shortage is specially acute of mechanical, electrical, and nuclear engineers, while the requirements for physicists and chemists are very nearly met. On the basis of the 1957 graduations there is said to be a shortage of 114 mechanical and 130 electrical engineers.

Plastics Exhibition

It is announced that the exhibition "Kunststoffe 1959" ("Plastics 1959") will take place in Düsseldorf from October 17 to 25, 1959. This is the third time since its inception in 1952 that the exhibition is being held. On an area of 60,000 square metres manufacturers and associated firms will show a full range of plastic materials, conversion products, and machinery and equipment. A new three-storey hall of 22,000 square metres exhibition space will be in use which will form a focus and permit close spacing of the exhibits. The exhibition will be international in its scope, and a number of international conventions are being arranged to take place simultaneously.

* See THE ENGINEER, page 279, August 23, 1957.

Progress in Controlled Thermonuclear Research in the United States

BY OUR AMERICAN EDITOR

No. I

During the past seven years the U.S. Atomic Energy Commission has been engaged in a research programme aimed at producing power from controlled nuclear fusion. The research effort is necessarily shaped by the physical conditions that must be achieved in order to realise net power from fusion. These physical conditions apparently have been defined, and promising methods of achieving them have been formulated. Significant progress has been made along several lines of effort ; each is contributing knowledge to the art of controlling fusible material for the achievement of a self-sustaining thermonuclear reaction. This article describes some of the more important classes of experimental devices developed at the four major laboratories working in the field and the principles and methods applied in these machines to overcome the two fundamental problems of attaining extremely high temperatures and of confining the plasma.

THE Atomic Energy Commission has made steady progress in its efforts to achieve sustained controlled thermonuclear reactions. The release of energy through fusion of atomic nuclei may ultimately be used to generate useful quantities of economically produced electricity. However, this remains a very long-range prospect. In connection with the publication of a group of papers in this country and in the United Kingdom, Mr. Lewis L. Strauss told a press conference on January 24 : " To-day's announcements make it clear that fruitful and promising results have been achieved in the laboratories of both countries, but we should not expect early harnessing of fusion for the production of power." The progress made cannot yet be measured in terms of the attainment of major goals, but important results have been won. It is felt that the prospects of power from nuclear fusion are sufficient to warrant a continuation of the expanding research and development programme. In all four major laboratories at work on the programme—Los Alamos Scientific Laboratory, Oak Ridge National Laboratory, Princeton University, and the University of California Radiation Laboratory—there has been steady progress. They are exploring a number of different methods of attack, which are described later in this report, and so far no insurmountable obstacles have appeared. Significant progress has been made in each of the several lines of effort ; each is contributing to knowledge and the new technology. There is general optimism about reaching what is called ignition temperature, i.e. a self-sustaining controlled thermonuclear reaction. When that point is reached, the effort to produce net fusion power will have attained a stage comparable to that reached in the use of fission on December 2, 1942 —the date when Enrico Fermi and his colleagues first demonstrated a self-sustaining fission chain reaction.

Assuming that some day a fusion reactor fuelled with heavy hydrogen can be operated successfully, it may be expected to have the following advantages : (*a*) The fuel costs would be extremely low. At present, deuterium (heavy hydrogen) costs about 140 dollars a pound to produce. If its nuclear energy content could be converted completely into electrical energy, a pound of deuterium could yield 40,000,000kW-hours of electricity. The gross fuel cost would be only 0·0035 mills per kilowatt-hour. (1 mill = 0·001 dollar.) This figure does not, of course, consider the operating efficiencies of the power plant, or the capital costs of the reactor which may be considerable ; (*b*) The fuel supply would be virtually unlimited. Heavy hydrogen exists in all surface waters of the world—the total of this deuterium is estimated at 10^{17} lb ; (*c*) A fusion power plant would be extremely safe. All calculations indicate that a nuclear explosion could not occur, and the risk of runaway or explosion appears to be about the same as for an ordinary coal-fired power plant ; (*d*) The radioactive hazards would be low. Radioactivity will be induced in the material surrounding the reactor, but the fusion reaction will not create large quantities of long-lived radioactive by-products that must be disposed of ; (*e*) The plant efficiency may be high. A part of the energy released in fusion reactions in a power plant might be convertible directly into electricity without the loss of efficiency that occurs in heating a cooling agent and using the transferred heat to drive a turbo-generator.

Programme Objectives

The ultimate objective of the Commission's programme of controlled thermonuclear research is to develop means of producing useful power from the energy released in nuclear fusion reactions. In thermonuclear reactions, fusible material—such as heavy hydrogen, or deuterium —must be heated to extremely high temperatures in order to initiate the fusion of the nuclei of its atoms. Such thermonuclear reactions are achieved in the hydrogen bomb with the relatively uncontrolled release of enormous amounts of thermonuclear energy ; energy is produced at an exceedingly great rate for a very short time. The production of fusion power for the generation of electricity—the objective of the programme—requires a great deal more control over the reaction. Thermonuclear reactions, controlled by natural forces, have for some time been recognised as the source of the energy which the sun and the stars have been radiating for billions of years.

To harness nuclear fusion reactions for the production of power on earth, three goals must be reached successively : (1) A fusible material must be heated to the ignition temperature—the threshold temperature for a self-sustaining reaction. At this point, energy is being released within the fuel at a rate sufficient to offset the loss of energy from the fuel by radiation. For fusion fuels consisting of heavy hydrogen, this ignition temperature is of the order of 100 million deg. Kelvin. (2) After ignition temperatures have been achieved, a machine—a fusion reactor—must be designed that will produce an excess of power ; more power than is consumed in operating the machine. (3) Production of power from a fusion reactor must be made economically competitive with electricity produced by other means. At present, the main effort of the programme is directed toward achieving the first goal—ignition temperatures. There is a general belief that these temperatures will be reached within a year or two. A device operating at ignition temperatures would not necessarily be a net producer of power. A net power producer would have to compensate for all energy losses, and also supply power to all the equipment necessary to make the device run. There is no real proof that a thermonuclear reactor yielding net power can be built ; however, there is no proof it is impossible either. The achievement of fusion-energy release in a controlled manner is much more difficult than the achievement of explosive release and requires a markedly different approach.

Experience leads to the belief that several successive generations of machines of increasing complexity and power will have to be built and operated before a successful net power producer can be designed. Thus, the second goal is probably many years away. As for the economic power producer, no predictions made at this time have much validity. Although fuel costs apparently will be entirely negligible, costs of building and operating large fusion power plants cannot be calculated on a practical basis at this time. Present indications are that, if such reactors are feasible at all, they will probably be of very large size. On the basis of all that is known at present, it is reasonable to expect a long-time scale for obtaining an economic fusion power producer, if it can be achieved at all. A fission reactor first produced electricity in 1951. Production of electricity at costs competitive with those of conventional power plants has yet to be demonstrated in the United States.

In the fission reaction currently used in power reactors to produce electricity, energy is released by splitting the nuclei of certain types of heavy atoms, chiefly uranium 235. The fission fragments are lighter nuclei which have less total mass than the original nucleus, and the difference in mass (m) is converted into energy (E) in accordance with Einstein's formula $E=mc^2$, where c is equivalent to the speed of light. In the fusion reaction, two light nuclei " fuse " to yield a nucleus in which the nucleons (the constituents of the nucleus, protons and neutrons) are more tightly bound than they were in the two original nuclei. This tighter binding manifests itself in a slight decrease in mass. The difference in mass is converted into energy and appears as the kinetic energy of the reaction products. The heavy hydrogen isotopes—deuterium and tritium—are materials of choice for thermonuclear experiments. To cause fusion to occur, the two light nuclei must be brought very close together. Every nucleus carries a positive electrical charge in direct proportion to the number of positively charged protons it contains. Since similarly charged particles repel each other, the fusion cannot take place unless this mutual repulsion, called the coulomb force, can be overcome ; the coulomb forces increase with the number of protons in the nuclei.

Nuclei of the heavy hydrogen isotopes contain only a single proton. The deuterium nucleus (H^2 or, more usually, D) contains a proton and a neutron which carries no electrical charge, positive or negative ; the tritium nucleus (H^3 or, more usually, T) contains a proton and two neutrons. Deuterium exists in nature—in sea water, for example—in the ratio of one atom of deuterium to 6000 of ordinary hydrogen. Tritium, which is radioactive with a half-life of some twelve years, must be manufactured. Fusion of deuterium nuclei can be accomplished by bombarding a deuterium target—such as " heavy ice," D_2O—with a beam of high-velocity deuterons (deuterium nuclei) from a particle accelerator. The deuterons must have energies in the general range of 10,000 to 100,000 electron volts. The fusion reactions then occur in either of two ways with about equal probability : (*a*) Two deuterium nuclei may react to form a triton (tritium nucleus) and a proton, with the release of 4,000,000 electron volts of energy as kinetic energy of the triton and the proton ($_1D^2+{}_1D^2 \rightarrow {}_1T^3+p+4{\cdot}0$ MeV) or (*b*) They may form a helium-3 nucleus and a neutron, and release 3·25 million electron volts of energy ($_1D^2+{}_1D^2 \rightarrow {}_2He^3+n+3{\cdot}25$ MeV). Of the energy released in each reaction, the heavier product particle (the triton, or the helium-3 nucleus), ends up with about one-quarter of the total, and the light product (the proton or neutron) with about three-quarters.

The prospects of using this reaction for the production of energy are clear : although fairly high energies are necessary to make the reaction occur with suitable frequency, the fusion reaction yields a great deal more energy than this—about

3·6 MeV on an average compared to 0·01 to 0·1 MeV to initiate it. However, bombardment of a solid target by ions from an accelerator will not yield net power in an overall sense. Only a minute fraction of the total number of accelerated deuterons can be made to fuse with the target nuclei ; the rest lose energy by scattering interactions (non-fusion collisions) and slow down to the point where they no longer have energy enough to provide high probability of penetrating the coulomb barrier and accomplishing fusion.

Another fusion reaction of interest in producing power is the reaction between a deuteron and a triton ($_1D^2+{}_1T^3\rightarrow{}_2He^4+n+17{\cdot}6$ MeV). The bombarding energy needed to provide a given probability of this reaction is lower than for $D+D$, and the energy yield per reaction is higher. While the tritium for a fusion reactor would have to be manufactured, whereas deuterium occurs in nature, the first $D+D$ fusion reaction given above also produces tritium in about half the $D-D$ fusions. The $D-T$ reaction therefore has to be taken into account in considering practical utilisation of the $D-D$ reaction for practical utilisation of the $D-D$ reaction for energy production. There is another secondary reaction that can occur ($_1D^2+{}_1He^3\rightarrow He^4+p+18{\cdot}3$ MeV), but the probability of its occurrence is much lower and therefore, it may usually be neglected. The $D-D$ reaction then may be considered to result in the following :

$$_1D^2+{}_1D^2\rightarrow{}_1T^3+p+4{\cdot}0 \text{ MeV}$$
$$_1D^2+{}_1D^2\rightarrow{}_2He^3+n+3{\cdot}25 \text{ MeV}$$
$$_1D^2+{}_1T^3\rightarrow{}_2He^4+n+17{\cdot}6 \text{ MeV}$$

$$\text{or } 5\,{}_1D^2\rightarrow{}_2He^3+{}_2He^4+p+2n+24{\cdot}85 \text{ MeV}.$$

The energy released thus averages about 5 MeV for every deuteron which undergoes fusion. In practical terms, this means that the small amount of deuterium contained in 1 gallon of ordinary water is sufficient to make it the equivalent of about 300 gallons of petrol as a fuel. The cost of separating deuterium from ordinary water is only 2 or 3 cents per gallon of water processed. A mixture of deuterium and tritium has obvious advantages as a fusion fuel, chief among which is its relatively high reaction rate and the lower energies necessary to achieve the reaction. One possible method of manufacturing tritium would be to expose lithium-6 to fusion neutrons moderated to thermal energies ; upon capturing a neutron, lithium-6 splits into tritium and helium-4. For the $D-D$ reaction, the release of energy at a rate of 1000kW would be accompanied by the production of neutrons at a rate of about $2{\cdot}5\times10^{18}$ per second.

Research Problems

The main difficulties to be overcome in attaining ignition temperatures, the first goal of the effort towards fusion power, may be stated as follows : (*a*) The temperatures corresponding to the relative energies which the particles need in order to fuse are exceedingly high—capable of vaporising any material whatsoever. (*b*) The plasma must be suitably confined, with adequate density, while it is being heated to these extreme temperatures.

The high temperatures sought in controlled thermonuclear research represent the average velocities (or energies) which deuterons must maintain for appreciable periods, with essentially random movements in a confined space, in order for a considerable number of them to fuse. As described earlier, in order to overcome the coulomb barrier and accomplish fusion, two deuterons must be made to collide with high relative velocity. The probability of fusion occurring at a given relative energy is measured by the cross-section σ, which is the effective interaction area per target nucleus. Fig. 1 shows experimentally-determined cross-sections as functions of bombardment energy. The cross-sections are usually given in " barns " : 1 barn = 10^{-24} square centimetres. These curves were obtained by directing a beam of deuterons at a target containing deuterium, tritium, or helium-3, respectively. The most probable result of two deuterons colliding is that instead of fusing, they will bounce apart without reacting. An important consequence of this relatively high probability of scattering is that deuterons must, on an average, be forced to collide many times, in order to ensure that considerable numbers will fuse. At each scattering collision, there will be, in general, some exchange of kinetic energy. But if considerable numbers of deuterons in a confined volume are given similar energies, the

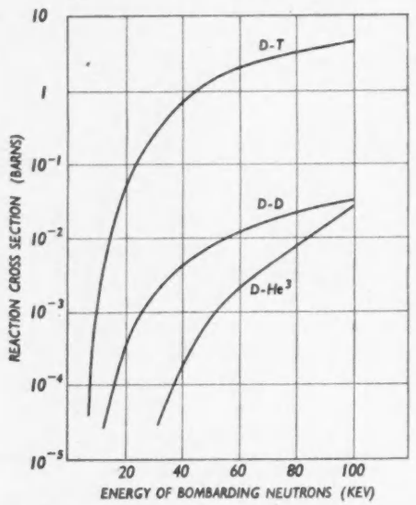


Fig. 1—Relationship of fusion reaction cross-section and bombarded energy of incident particle

multiple collisions will not, on an average, change the energies of the deuterons. Thus, after long pre-fusion paths, and many scattering collisions, the deuterons will still have sufficient relative energy for a fusion reaction to occur. To accomplish these repeated collisions, the energetic deuterons must be allowed to move essentially at random within a confined volume, just as molecules of air in a room have random motion. And to accomplish fusion, the temperature—the relative energies—of the deuterons must be very high. It may be recalled that, under equilibrium conditions, the distribution of particle velocities in a gas is such that their average kinetic energy is $3/2kT$, where k is the Boltzmann constant and T is the temperature of the system. From this, it can be calculated that, if deuterons are to be in random motion at the energies required for fusion, the temperature of the deuterons must be several hundred million deg. Kelvin. It is common practice to speak of temperature in terms of the energy kT rather than in terms of degrees : kT is the energy corresponding to the most probable velocity in a Maxwellian velocity distribution. A kT value of 1 keV corresponds to a T value of about 11,600,000 deg. Kelvin, 10 keV to 116 million deg., and so on.

The heating of matter to very high temperatures results in ionisation, i.e. atoms become stripped of the electrons which normally surround the nuclei. The resulting mixture of ions and electrons is called a " plasma." Deuterium heated to a temperature sufficient to provide a substantial reaction rate becomes a plasma consisting of deuterons and electrons in equal numbers. It is not essential for the ions and electrons to be at the same temperature. Through energy-exchanging collisions, the two temperatures will tend to be the same, but it is only the ion temperature which influences the fusion reaction rate, since it is the ions which must maintain sufficient velocities to fuse. The term " temperature " should be strictly applied only to systems which are in thermal equilibrium, i.e. systems in which average quantities such as the energy and density of a large number of particles do not change appreciably in the time required for the particles to interact with one another through collisions. Fusion reactions can occur in a plasma of fusible material which is not in thermal equilibrium. Nevertheless, attempts are directed principally toward heating deuterium in systems under conditions such that one can validly refer to the temperature of the system. A very close approach to thermodynamic equilibrium cannot be achieved in man-made fusion systems, but for ease of calculation it is generally assumed that the systems are in equilibrium. Consequently, it is assumed that the ions and electrons have the characteristic Maxwellian velocity distributions ; a distribution in which a few particles have extremely high velocities relative to the rest, some have very low velocities, and the bulk is in an intermediate range. Strictly speaking, the term " thermonuclear reactions " should be reserved for those fusion reactions which occur in hypothetical systems where the reacting nuclei are in thermodynamic equilibrium characterised by a unique temperature, or at least close to such conditions.

How to heat a low-temperature plasma to the extremely high temperatures required for fusion is a major problem. A number of methods involve applying electric fields to the plasma. The fields accelerate charged particles and impart energy to them. The passage of a current through a plasma results in ohmic or resistive heating. For inductive processes in which the current is not changing too rapidly, energy from the electric field is delivered preferentially to the electrons, which in turn share energy with the ions. However, the resistivity of a plasma decreases as its temperature is increased. At temperatures of the order of 1,000,000 deg., it is no longer practical to try to heat ions by using hot electrons. Resistive heating (I^2R) loses its utility because of the decrease in plasma resistance (R) and practical limits to the amount of current (I) that can be used. The heating techniques employed in various fusion experiments differ from one device to another and are described in more detail below.

Containing the hot plasma is fully as difficult as attaining the necessary temperatures. The plasma exerts an outward pressure proportional to the total number of particles per unit volume and to the temperature. Therefore, it tends to expand. The expansion of the hot plasma must be opposed at least long enough to allow a significant fraction of the fusible fuel to burn. It is necessary to work at fairly low densities in order to keep the pressure down to manageable levels. Plasma with a density of about one-ten-thousandth of normal atmospheric density will, at the extreme temperatures required, exert a pressure of the order of 1500 lb per square inch. The temperature required for ignition is independent of plasma density, but low density does result in a very long mean free path for nuclei—the average distance the ions will travel between collisions. Therefore, the mean fusion reaction time also is very long—of the order of seconds—and the average energetic deuteron will travel many thousands of miles before it reacts.

The confinement of a very hot dilute plasma is thus a major problem. Material walls cannot be used for direct confinement because hot particles from the central region would strike the walls, give up a good deal of energy, and return to the central region as cool particles. For any container of reasonable size, this would result in an intolerable drain on the energy of the system. Furthermore, contact between the plasma and the walls results in the introduction of impurities into the reaction zone, and these further increase energy losses. The plasmas of the stars and sun are confined by gravitational forces, but these forces are far too weak for the smaller systems with which experimenters on earth must work. It is generally agreed that magnetic fields provide the best means of confining a hot plasma. All experimental devices in the United States and, so far as is known, the rest of the world, make use of some form of " magnetic bottle," to confine the plasma and keep it centred in the reaction vessel. Material walls still must be used to separate the low-density plasma from the outside world, but magnetic fields serve to keep plasma away from the walls.

An electrically charged particle moving at right-angles to a magnetic field experiences a force perpendicular both to the direction of the field and to the direction in which the particle is moving. As a result of this force, an ion or an electron, moving in a plane perpendicular to a uniform magnetic field, will follow a circular path around a magnetic line of force. By means of magnetic fields attainable in a laboratory—say, 50,000 gauss—a deuteron moving fast enough to undergo fusion can readily be made to follow a path whose radius is of the order of inches. Motion in a direction parallel to the

magnetic field's lines of force is unaffected by the field, so that in general a charged particle follows a helical, or spiral path along a line of force in a strong uniform field. Fig. 2 illustrates

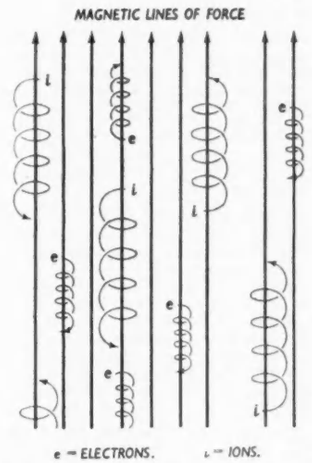


Fig. 2—Movements of ions and electrons along lines of force in a magnetic field

the motion of charged particles in such a uniform magnetic field. The particle is, in effect, " tied " to the magnetic line of force. Lines of force are fictions which are useful in portraying the " shape " and intensity of a magnetic field configuration.

The particle pressure and density will tend to be low in regions of an equilibrium system where the magnetic field is high, and vice versa. The confining magnetic fields may be produced by current-carrying coils outside the system or by currents passing through the plasma itself. Under ideal conditions, a magnetic field of 50,000 gauss, existing outside the plasma and thereby containing it, could withstand a particle pressure of about 100 atmospheres. Additional forces come into play if the magnetic field is not uniform, or if an electric field is applied. In some cases, these forces can be used to good advantage ; in others, drifts of particles among otherwise randomly moving particles can lead to a reduction in the degree of confinement. A number of different magnetic field configurations have been employed in attempts to solve the confinement problems and some are described in detail below.

The achievement of a net power balance—the energy level represented by the ignition temperatures—is a problem involving competition between the rate of nuclear energy production by fusion within the reacting plasma and the rate of energy loss by various means through the outer surface of the plasma column. The fusion reaction rate per unit volume of ions in the plasma is given by $\frac{1}{2}n_i^2\bar{\sigma v}$ where n_i is the density of reacting nuclei, σ is the reaction cross-section, and v is the relative velocity of the reacting particles. The bar denotes an averaging since

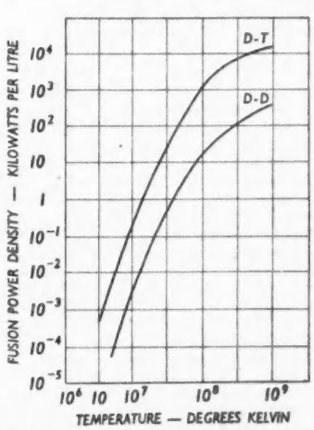


Fig. 3—Relationship of fission power density and plasma temperature

there is a distribution of velocities, and the cross-section is velocity dependent. At moderate temperatures, only the fastest nuclei will be reacting at any appreciable rate ; the slower nuclei do not participate in proportion to their greater numbers. The expression must be modified if more than one type of nucleus is reacting. Multiplying the reaction rate by the energy yield per reaction gives the power density. Fig. 3 depicts the power density as a function of temperature for a particle density 10^{-4} that of normal atmosphere and shows that the rate of energy production is strongly dependent on temperature.

Radiation is a primary and unavoidable cause of energy loss, and the pressure exerted by the radiation would become impossibly large. The saving circumstance is that the plasma column in fusion reactors will not be dense enough or physically large enough to radiate like a black body, and the radiation will escape immediately from the surface of the plasma column. Losses of energy may occur through the following means: (*a*) Radiation, including (1) the so-called " braking radiation " of electrons resulting from coulomb interactions, chiefly electrons in collision with ions ; and (2) the excitation of partially ionised impurities in the plasma. (*b*) Particles, including leakage of particles from the magnetic field, either along lines of force which intersect a wall of the reaction chamber, or by migration across lines of force, or through becoming neutralised by charge-exchange processes. (*c*) Collective movements of particles through instabilities of various kinds.

(*a*) *Radiation.*—Bremsstrahlung (" braking radiation ") is emitted copiously as a result of coulomb interactions in the plasma. The bremsstrahlung loss—essentially soft X-rays—exceeds the nuclear energy production at low temperatures, but it increases with rising temperatures less rapidly than does the production of fusion energy. At sufficiently high temperatures, the rate of energy release in the form of kinetic energy of the charged reaction products will exceed the bremsstrahlung loss. The temperatures at which fusion power release equals the radiation loss is the ignition temperature. (Neutrons are not taken into account in calculating ignition temperatures, since the neutrons are not confined by magnetic fields and immediately escape from the system, carrying their energy with them.) The ignition temperature is independent of density since both fusion and radiation processes both depend on two-particle reactions. The fusion " flame " can be thought of as self-sustaining above this point (excluding burn-up of fuel and other energy losses) without additional external contributions of energy to maintain the temperatures. For deuteron-deuteron fusion, the kT value for ignition is 35 keV (about 400 million deg.) ; for the deuteron-triton reaction, about 4 keV. At these ignition temperatures and the densities proposed, the thermonuclear flame would be almost invisible. It would produce enormous quantities of soft X-rays but these would not penetrate even a thin window. It would also produce enormous quantities of protons and helium nuclei which would remain in the system, and of neutrons which would escape. Bremsstrahlung losses are greatly increased by the presence in the plasma of impurities of high atomic number. Another type of radiation loss traceable to impurities is excitation radiation, which can be very troublesome at relatively low temperatures. Partially ionised impurities readily absorb energy from electrons in the plasma and promptly radiate it away in a continuous or cyclic fashion. This effect disappears if the impurities become completely ionised, as they do at higher temperatures.

(*b*) *Particles.*—Energy is lost from the system when energetic charged particles escape from the magnetic fields that confine them. Charged particles moving freely along lines of force may leak out of the reaction zone if the lines intersect the walls of the reaction chamber. Another loss process is diffusion, or migration of particles across the magnetic field, which results from repeated collisions between particles. A particle " tied " to a line of force may transfer to another line of force when it suffers a collision, and move progressively toward the reaction chamber wall. From the standpoint of this type of diffusion alone, no " magnetic bottle " can be made completely leakproof. The process of charge-exchange leads to another kind of loss. Fast ions become neutralised by picking up electrons through collisions with slow neutral atoms or molecules which have wandered into the system. Since magnetic fields bind only charged particles, the fast neutral atoms thus produced quickly escape from the plasma, leaving slow ions behind. This effectively cools the system. The cross-section for charge-exchange between a deuteron and a deuterium molecule has a broad peak at about 15 keV, where its value is 14×10^{-16} square centimetres, or 1400 million barns ! This is to be compared to the cross-section for the fusion reaction, which is of the order of only 1 barn. The deuteron-deuterium cross-section falls very steeply as deuteron energy increases beyond 15 keV. Charge-exchange losses and excitation radiation losses point up the need for minimising contamination of the plasma, operating with extremely clean systems and keeping cold neutral atoms out of the system by high-speed vacuum pumps.

(*c*) *Collective Motion.*—Instabilities of the plasma, or imperfect confinement on a gross scale, can obviously cause large losses by throwing plasma bodily into the reaction chamber walls. One of the most complex problems in the field of plasma physics is the analysis of such co-operative phenomena taking place in a completely ionised gas. These phenomena include a host of macroscopic effects arising from the concerted motion of very large numbers of electrons and ions interacting with electromagnetic fields. Thus, the behaviour of a plasma must be studied not only from a single-particle standpoint, but also from a collective, or fluid dynamics, standpoint. One concerns the statistical behaviour of large numbers of particles acting independently ; the other concerns gross behaviour of a large number of particles which are acting collectively as a result of long-range interactions between them. Two major classes of instabilities plague systems in which hot plasma is confined by magnetic fields. Hydromagnetic instabilities are associated with an imbalance between the magnetic energy of the field which compresses the plasma, and the compressional energy of the plasma. Under the influence of some perturbation, either force can drive the system away from equilibrium. The kink instabilities which afflict the pinch discharge are of this type. Fig. 4 indicates the two types of

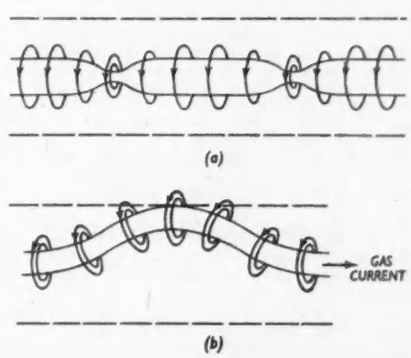


Fig. 4—Hydromagnetic instabilities observed in pinch discharges : (*a*) " sausage " instability ; (*b*) kink instability

hydromagnetic instabilities observed in pinch discharges : (*a*) the so-called " sausage " instability, and (*b*) the kink instability. The horizontal dotted lines represent the walls of the reaction chamber, the arrowed circular lines the lines of magnetic force. The other class of instabilities is of an electrostatic nature. Such unstable motions are driven by electrical energy associated with the electric fields in the plasma. Electric fields can lead, for example, to bunching of fast electrons and deleterious secondary effects. A plasma can become unstable in a variety of ways. Probably some modes of unstable motion have not been discovered, much less understood. The question of stability is a crucial one in the fusion research field.

(*To be continued*)

Personal and Business

Appointments

MR. B. R. CANT has been appointed managing director of Hamworthy Engineering, Ltd.

MR. F. V. WALLER, M.I.P.E., has been appointed a director of Southern Areas Electric Corporation, Ltd.

MR. R. W. JELBART has been appointed sales manager of the thermostat division of R. B. Pullin and Co., Ltd.

ELLIOTT BROTHERS (LONDON), Ltd., has announced that Mr. F. J. Shields has joined the company as service manager, aviation division.

THE BRITISH TRANSPORT COMMISSION announces that Dr. H. I. Andrews has been appointed assistant electric traction engineer (research).

METADUCTS, Ltd., announces that Mr. B. D. Bowman, A.M.I.Mech.E., will join the company on October 20, as technical sales manager.

THE ELECTRICITY COUNCIL has appointed Mr. Malcolm Skinner to be joint consultation officer in the Council's industrial relations department.

BRITISH WELDING RESEARCH ASSOCIATION states that Dr. R. Beeching, Mr. J. M. Willey and Mr. T. M. Herbert have been elected members of the council.

WICKMAN, Ltd., announces that Mr. J. Hodkinson has been appointed a director with overall responsibility for the company's machine tools export interests.

HEAD WRIGHTSON AND CO., Ltd., has announced the appointment of Mr. George Taylor as assistant general manager of Head Wrightson Steel Foundries, Ltd.

THE CENTRAL ELECTRICITY GENERATING BOARD has announced that Mr. J. B. Jackson, M.I.Mech.E., M.I.E.E., has been appointed divisional controller of the north-eastern division.

MR. ROBERT HUGH DIBB has been appointed engineering controller of Imperial Chemical Industries, Ltd., in succession to Mr. John Edgar Braham, who has retired from the company.

THE CONSETT IRON COMPANY, Ltd., announces the following appointments :—Mr. S. C. Pearson, assistant general manager, and Mr. G. F. Ewan, general works manager (production).

THE BRITISH INTERNAL COMBUSTION ENGINE RESEARCH ASSOCIATION announces that Viscount Falmouth has been re-elected president. Sir Harold Roxbee Cox, Mr. H. N. Pemberton, Professor O. A. Saunders and Brigadier S. A. Stewart have been re-elected vice-presidents. Rear-Admiral W. F. B. Lane has also been elected as a vice-president.

METROPOLITAN-CAMMELL CARRIAGE AND WAGON COMPANY, Ltd., has announced that Mr. Harry Green, director and chief engineer, has retired from the company's service and relinquished his seat on the board of directors, having reached normal retiring age. Mr. D. J. C. Robertson, a director, has been appointed general manager, Mr. J. L. R. Barnes, chief engineer (carriages and wagons), and Mr. C. J. E. Large, chief engineer (railcars). Mr. Barnes has also been appointed a special director.

Business Announcements

ACHESON INDUSTRIES (EUROPE), Ltd., has moved to 1, Finsbury Square, London, E.C.2 (telephone, Monarch 5811).

THE TRUSSED CONCRETE STEEL COMPANY, Ltd., 35–41, Lower Marsh, London, S.E.1, states that its name has been changed to Truscon, Ltd.

JOHN TAYLOR, DUNFORD AND CO., Ltd., states that its Sheffield branch has been moved from 37, Wicker Street, to 173, Attercliffe Road.

OTTERMILL SWITCHGEAR, Ltd., is moving its London offices to new premises at 82, Victoria Street, London, S.W.1 (telephone, Abbey 5095–6).

CHAMBERLAIN AND WILLOWS, 23, Moorgate, London, E.C.2, have been appointed sole agents for the industrial developments in the new town of Corby, Northants.

WILD-BARFIELD ELECTRIC FURNACES, Ltd., Elecfurn Works, Otterspool Way, Watford By-Pass, Watford, Herts, states that its telephone number has been changed to Watford 26091.

MR. R. GOODBURN, export sales manager of the Surform division of Simmonds Aerocessories, Ltd., and Mr. P. W. Newby, publicity manager of the Firth Cleveland Group, are to visit Germany early in November.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., and W. T. HENLEY'S TELEGRAPH WORKS COMPANY, Ltd., have concluded negotiations to amalgamate the cable and other manufacturing resources of the two companies.

MASCHINENFABRIK SACK G.M.B.H., Duesseldorf-Rath, W. Germany, has appointed D.M.M. (Machinery), Ltd., 66, Victoria Street, London, S.W.1, as its accredited representative for Great Britain and Ireland.

B. ELLIOTT (MACHINERY), Ltd., Victoria Works, Willesden, London, N.W.10, states that the hydraulic open-sided planers previously known as " Hydetsco " will in future be sold under the name " Invicta-Hydetsco" as they are now a product of the B. Elliott Group.

PRIESTMAN BROTHERS, Ltd., announces that it has made new arrangements to cover the north-west area with sales and service personnel. Mr. A. Chamberlain, 9, Mayfield Grove, Cuddington, Northwich, has been appointed N.W. area sales representative, and Mr. Herbert Dukes, 10, Glenthorn Avenue, Sale, Cheshire, resident service engineer.

Contracts

THE POWER-GAS CORPORATION, Ltd., Stockton-on-Tees, has received an order for a semi-water gas plant, having a productive capacity of 189,000 cubic feet per hour of $CO+H_2$ from coke, from Societe Iberica de Nitrogeno of Madrid for its Felguera Works. The plant will comprise an 11ft 6in internal diameter water-sealed generator with combustion chamber and waste heat boiler. The cyclic operation will be controlled by the P-G automatic controller.

THE B.I.C.C. GROUP has received orders from the National Telephone Company of Venezuela, the total value of which exceeds £500,000. These contracts cover the supply and installation of trunk and distribution telephone cables for the new Boleita exchange on the eastern outskirts of Caracas. The cables will be manufactured and supplied by British Insulated Callender's Cables, Ltd., in Great Britain and the laying and jointing of the cables will be carried out by Constructora B.I.C.C. de Venezuela.

AVELING-BARFORD, Ltd., has received a contract from the Imperial Highways Authority of Ethiopia for thirty 99H motor graders to be delivered over the next five months. With spare parts and extra attachments such as bulldozers and elevating graders, the order is valued at about £200,000. The contract was negotiated through Luke, Thomas and Co., Ltd., the Aveling-Barford distributors in Ethiopia and will be paid for from World Bank loan funds. Another contract is that from the Nigerian Railway Corporation for quarry plant to the value of £100,000 to produce ballast for rail extensions at Bornu. This order comprises three Goodwin Barsby two-unit " Goliath " mobile crushing and screening plants which will be fed by six Aveling-Barford 4½ cubic yard diesel " Shuttle " dumpers.

Miscellanea

THE CYCLE AND MOTOR CYCLE SHOW.—The 1958 Cycle and Motor Cycle Show, which takes place from November 15 to 22, at Earls Court, London, will be officially opened by the Rt. Hon. Harold Watkinson, Minister of Transport and Civil Aviation, at 11 a.m. on Saturday, November 15.

WRECK RETURNS.—Lloyd's Register of Shipping has issued its statistical summary of merchant ships totally lost, broken up, &c., during 1957. The world total of ships lost consequent upon casualty equals 163 ships of 270,963 tons gross, of which 18 ships of 32,279 tons were owned by Great Britain and Northern Ireland. Corresponding figures for ships condemned, broken up, &c., amounted to 341 ships of 729,939 tons gross and 149 ships of 353,998 tons respectively.

CONDITIONS OF TENDER FOR HEATING AND VENTILATING SUB-CONTRACTS.—We are informed by the Association of Heating, Ventilating and Domestic Engineering Employers that it has negotiated with the Association of Consulting Engineers conditions of tender for sub-contracts. The councils of both associations have approved documents covering conditions of tender, form of tender, and an appendix and schedule for " heating, ventilating and domestic engineering " sub-contracts.

CENTRAL ELECTRICITY GENERATING BOARD BULK SUPPLY TARIFF.—The Central Electricity Generating Board has announced that it has reduced the " running charge " of its bulk supply tariff as from October 1, 1958, for the remainder of the current financial year ending March 31, 1959. The old tariff, which applied to all area boards on a uniform basis subject only to an area fuel cost adjustment, was of two-part structure, incorporating a fixed charge of £6 per kilowatt of maximum demand and a " running charge " of 0·47d. per unit. The " running charge " was reduced from 0·47d. to 0·46d. per unit as from October 1.

LIFTING PLATFORM.—A hydraulically operated lifting platform or table unit now being made by Access Equipment, Ltd., Hemel Hempstead, is designed to simplify the problems of lifting, positioning and feeding materials to production machines. It has a power unit, consisting of electric motor and hydraulic components built into the base frame and the eleven different models available have capacities from 10 cwt to 3 tons. Platform sizes vary from 4ft 8in by 2ft 8in to 8ft 3in by 4ft, and have work lifting strokes up to 3ft 3in.

UNWROUGHT ALUMINIUM FROM THE U.S.S.R.—The Soviet authorities have informed the Board of Trade that Raznoimport, the foreign trade organisation which alone is empowered to sell Soviet aluminium, will not export more than 15,000 tons of unwrought aluminium to the United Kingdom in the next twelve months. At the same time, the Board of Trade announces that it has decided to take no further action on the application by the Aluminum Company of Canada, Ltd., for an anti-dumping duty under the Customs Duties (Dumping and Subsidies) Act, 1957.

TAR SURFACE DRESSINGS.—The Road Research Laboratory has published a new edition of its " Road Note No. 1 " which is on tar surface dressings. Further experience is embodied in this new edition covering the surface dressing of roads carrying very heavy and very light traffic, and more definite recommendations are made for rates of spread under different conditions and with viscosities encountered in modern practice. Recommendations are included for surface dressing at difficult sites such as bends, hills and roundabouts where traffic is heavy and fast, and on main roads in very hot weather.

BERYLLIUM PLANT.—It is announced that Imperial Chemical Industries, Ltd., Metals Division, is to establish the first plant in Europe for the production of wrought beryllium. The plant is designed to produce semi-fabricated forms of the metal, such as rod, tube and plate, and finished machined parts. Its first job will be the execution of a production scale contract placed with I.C.I. by the United Kingdom Atomic Energy Authority (Industrial Group) as part of a nuclear development project. It is expected that subsequent spare capacity may find additional outlets for the metal such as in the aircraft industry.

MR. C. J. INGLIS.—We have learned with regret of the death of Mr. Cyril J. Inglis, which occurred on September 29 at the age of sixty-six. He was a former librarian of the Institution of Civil Engineers from which office he retired only a year ago after forty-four years' service. He joined the Institution's staff when the present headquarters building was being erected in Great George Street, Westminster, just before the first world war. After service in that war, Mr. Inglis was appointed assistant librarian and subsequently chief librarian. There are numerous engineers who will recall not only his expert librarianship but also his encyclopædic memory.

CHEMICAL TREATMENT FOR FUEL OILS.—The Amber Chemical Company, Ltd., 11a, Albemarle Street, London, W.1, has announced the development of two products to improve combustion of fuel oils. It is claimed that small additions of Amber S.S.R.511 to fuel oils will reduce to a harmless level the formation of sludge and improve the stability of fuel oils made up of straight-run distillates and components produced in catalytic cracking units. Amber S.S.R.513 added to diesel fuels tends to soften and break up the binders in carbon and lower its ignition point, thus preventing the formation of hard deposits. Furthermore, since carbon is absorbent to sulphur, the rate of sulphur attack will be reduced.

STRESSED STEEL GIRDER FOR UNDERPINNING.—A girder with a stressing device which enables it to take up its load without the necessity for wedging or jacking to induce a deflection has been developed by Joseph Westwood and Co., Ltd. Its main uses are in the strengthening of floors, where the stressing procedure allows it to act with existing girders in taking a given share of the load ; for spreading reactions on walls; and for underpinning walls. The girder may be made up of two or more lengths. The joints are made with high-tensile steel bolts, nuts and washers, which are tightened to a predetermined torque by torque spanners. The principle of the girder is that when erected the joints are left slightly open on the tension side, so that the girder assumes a predetermined curvature which will be, in general, its calculated deflection under load. The girder is then packed solid to the wall or floor imparting the load, and the bolts in the joints systematically tightened The action of tightening these bolts closes the joints and stresses the tension flange of the girder, thus enabling the girder to take up its load without deflecting.

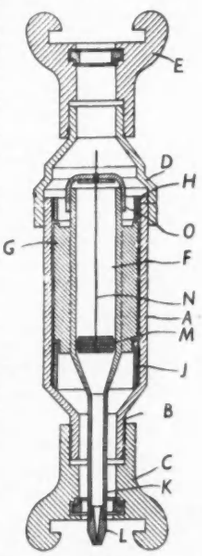
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

LUBRICATION DEVICES

800,463. May 1, 1956.—Lubrication Apparatus for Machines Driven by Compressed Air, Paul Beckmann, 91, Saarlandstrasse, Dortmund, Germany.

The invention relates to an apparatus for the lubrication of machines driven by compressed air, such as, for example, rope winches, elevators, coal-cutters, or riveting hammers. The object of the invention is to provide an apparatus which will remove previous disadvantages, and by means of which the lubricant will be supplied continuously, and over a long period to the points where it is required. The apparatus shown in the drawing comprises a hollow cylinder *A* having at one end a neck *B* which is threaded for attachment to a connecting piece, e.g. a bayonet lock *C* for connecting to the machine. The other end of the cylinder screws into an adaptor *D* on which is a bayonet lock *E* for connection with a compressed air conduit. A container *F* filled with oil is inserted in the cylinder and is centred by spacers *G* and is secured by collars *H* and *J*. The oil container has a neck *K* in which a nozzle *L* is screwed so as to be controllable in known manner in relation to the flow. In the container is provided a piston *M* which is fixed to a rod *N* guided in an end plate *O*. During operation, this piston is struck on the rear side by the compressed air and pushed forward as the compressed air penetrates into the container through the annular clearance between the piston rod *N* and the plate *O*. Therefore, dependent upon the dimensions of the clearance, a quantity of oil is forced through the nozzle *L*. The oil is then atomised by the compressed air rushing past the nozzle and is conveyed in this form to the lubricating points. The filling of the oil container is effected by unscrewing the nozzle, whereupon the oil can be drawn into the container *F* by immersing the end in the oil and by retracting the piston *M* by means of the piston rod. By examination of the position occupied by the piston rod after loosening of the rear bayonet lock *E*, it is readily ascertainable whether or not a refilling of container *F* is necessary. In order to be completely independent of the responsible servicing personnel, it is desirable to ensure that the compressed air is shut off at a determined position of the piston in the oil container, and the apparatus for this purpose is described in the specification along with modified designs.—*August* 27, 1958.

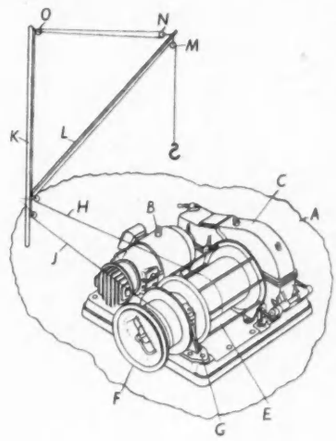


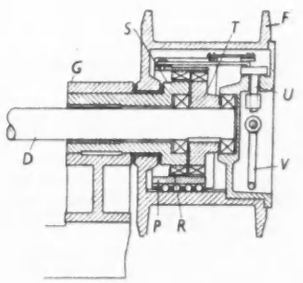
No. 800,463

CRANES AND WINCHES

800,728. April 18, 1957.—Marine Winches, Allmänna Svenska Elektriska Aktiebolaget, Västeras, Sweden.

Hoisting means on board ships for loading and discharging cargo are often driven by a winch. According to the invention, a winch having two or more cable drums mounted on a common shaft is characterised in that one end of the drum is arranged on the shaft at one end, outside the shaft supporting bearing. In that drum an axially movable clutch member is arranged. Referring to the drawing, the hoisting device is mounted on the deck of a ship *A*. The winch of the hoisting device comprises a winch motor *B* which drives a gear *C* and a shaft *D* on which the drums *E* and *F* are arranged. The drum *E* which is between the gear *C* and a supporting bracket *G* is intended for the hoisting cable *H*. The drum *F* mounted at the end of the shaft *D* outside the bracket is intended for the jib-adjusting cable *J*. *K* is a post and *L* a jib which, at its lower end, is pivotally journalled on the post. At its free end the jib carries pulleys *M* and *N* for the hoisting and jib-adjusting cables respectively. The drawing clearly shows the manner in which the winch drum and its gearing are constructed. When the winch is to be used for hoisting cargo only the drum *E* is connected to the shaft *D*. The clutch member *P* is then in the position shown in the drawing, in which the gear ring *R* is in mesh with the gear wheel *S* secured to the bracket *G*. Under these conditions, the drum *F* is prevented from rotating. When it is desired to adjust the position of the jib *L* the gear wheel *T* is turned into a position in which its teeth are exactly opposite to the teeth of the wheel *S*. The shaft *U* is then turned by the arm *V* through 180 deg., so that the clutch member *P* and the ball race are moved to the right. When the clutch member has moved into its right-hand position the drum *F* is secured to the shaft *D* and is then driven by the winch motor. The jib adjusting cable *J* may then be wound. The distance between the gear wheels *S* and *T* is so small that the internal gear ring *R* meshes with both the gear wheels during the change-over movement. This prevents the drum from rotating out of control, which could happen if the clutch were locked to the winch stand by one clutch member and connected to the shaft by the other clutch member. The invention is, of course, not limited to the embodiment shown in the drawing, and the clutch member and the drum may be provided with splines.—*September* 3, 1958.



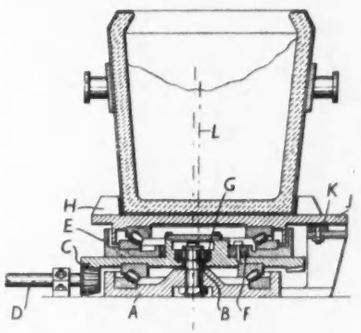


No. 800,728

METALLURGY

801,156. June 11, 1956.—A Method for Treating Molten Metal, Stora Kopparbergs Bergslags Aktiebolag, Falun, Sweden.

The invention relates to a method for the treatment of metal melts, and particularly to a method of obtaining an effective stirring action when treating a metal melt with a solid or gaseous refining agent. The apparatus shown in the drawing comprises a stationary base *A* which carries a vertical stub-shaft *B*. A circular lower table *C* is mounted on roller bearings. The table *C* has peripheral bevel teeth gear meshing with a bevel gear on a shaft *D* which may be driven in any suitable manner. An annular disc *E* rests upon the lower table and has its axis eccentric to that of the stub-shaft. The extent of this eccentricity can be regulated by rotating a ring *F*, which also rests on the lower table *C* and has its inner and outer peripheries, which are mutually eccentric, in contact respectively with the outer periphery of the boss *G* and the inner periphery of the annular disc *E*. An upper table *H* is supported on disc *E* by roller bearings which are concentric with the axis of the disc, and the furnace ladle or other vessel containing the molten metal bath to be treated is supported on this table. This table has a lateral extension *J* presenting a radial keyway in which works a key *K* pivoted to a portion rigid with the base *A*. In operation, the vessel performs a circular motion, due to the eccentricity of the disc *E* and the table *H*, but it does not rotate, on account of the key *K*. The axis of the vessel is slightly to the right of the axis *L*, as will be seen from the drawing, and it also rotates. The movement of the vessel about its axis is confined to a slight oscillation. The desired movement of the table *O* can be effected in other ways and the table can be made large enough to hold several vessels. The bath in the vessel *R* will be effectively agitated by the aid of the friction of the molten metal against the wall of the vessel. The intensity of the mixing is determined in part by the eccentricity and part by the rate of rotation of the table *C*. The method according to the invention may be used for various metallurgical reactions such as the desulphurising of crude iron and for refining crude iron with oxygen, for which the new method has great possibilities.—*September* 10, 1958.

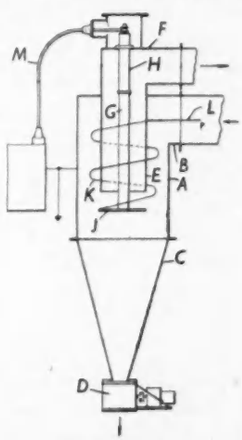


No. 801,156

GAS PLANTS

800,345. April 21, 1955.—Gas Cleaning, W. C. Holmes and Co., Ltd., Whitestone Iron Works, Turnbridge, Huddersfield, Yorkshire, and William Sykes, 11, Park Grove, Huddersfield, Yorkshire. (*Inventor: Norman Hinchliffe.*)

The invention concerns cyclones for the extraction of suspended particles such as dust from gases, its object being to provide a cyclone of increased efficiency without involving the additional complication of operating in series with an electrostatic precipitator. The drawing is a diagrammatic side elevation showing a reversed flow ionising cyclone which comprises a substantially cylindrical body *A* with a tangential inlet *B* at its upper end, a frusto-conical collection hopper *C* attached to the lower end of the body with a motor-driven conveyor *D* for removal of separated solid matter, and a coaxial uptake duct *E* within the upper part of the body leading to a radially extending outlet *F*. A depending rod *G* supported from an insulated high tension connection *H* has a circular plate *J* at its lower end. At one edge of this plate there is attached the lower end of a helical rod or wire electrode *K*, the upper end of which merges into a straight portion *L*, coaxial with the inlet *B* and constituting a pre-ionising electrode. The body *A* is earthed and a high tension supply is fed by way of an insulated cable *M* to the connector *H*. A straight-through ionising cyclone is also shown in the specification. The invention may also be applicable to the separation of non-conducting particles by introducing another substance into the gas stream to render these particles conductive or to induce their agglomeration under ionising conditions. —*August* 27, 1958.



No. 800,345

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., Oct. 13.—BOURNEMOUTH BRANCH : Grand Hotel, Firvale Road, Bournemouth, Hants, " Trivector Metering," J. Collins, 8 p.m. ★ CENTRAL LONDON BRANCH : Visit to the Electrical Association for Women, Foubert Place, London, S.W.1, 7.15 p.m. ★ NORTH WEST LONDON BRANCH : Century Hotel, Forty Avenue, Wembley Park, " Earthing," S. J. Emerson, 8.15 p.m.

Tues., Oct. 14.—PORTSMOUTH AND DISTRICT BRANCH : Ministry of Labour and National Service, Lake Road, Portsmouth, " Radio Frequency Heating," P. B. Curtis, 7.30 p.m. ★ SOUTH WALES BRANCH : Angel Hotel, Cardiff, " Silicones in the Electrical Industry," J. Davies, 7.30 p.m. ★ WEST KENT BRANCH : Rose and Crown Hotel, Tonbridge, " The Area Board's Views on the Testing of Installations," G. H. Ingamells, 7.30 p.m. ★ YORK BRANCH : " Georgian House," Blossom Street, York, " Electrical Control of Oil-Burning Equipment," 7.30 p.m.

Wed., Oct. 15.—WOLVERHAMPTON AND DISTRICT BRANCH : Chamber of Commerce, District Bank Chambers, Lichfield Street, Wolverhampton, " Applications of Electricity to Mining," G. W. Hall, 7.45 p.m.

Sat., Oct. 18.—OXFORD AND DISTRICTS BRANCH: St. John's Hall, Marston Street, Oxford, " The Organisation of the A.S.E.E.," E. A. Bromfield, 7 p.m.

BRITISH EMPLOYERS' CONFEDERATION

Thurs. and Fri., Oct. 16 *and* 17.—Church House, Westminster, London, S.W.1, Conference on " Industrial Relations."

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Oct. 15.—SOUTH WALES SECTION : College of Advanced Technology, Cardiff, " Principles of Transistor Circuitry," B. R. A. Bettridge, 6.30 p.m. ★ MERSEYSIDE SECTION : University Club, " The Manufacture of High Frequency Surface Barrier Transistors," P. A. Charman, 7 p.m.

DIESEL ENGINEERS AND USERS ASSOCIATION

Thurs., Oct. 16.—Memorial Building, Institute of Marine Engineers, 76, Mark Lane, London, E.C.3, Annual General Meeting ; " Automatic Control of Engine Driven Plants," E. R. Hill, 2 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Oct. 13.—SHEFFIELD CENTRE : Grand Hotel, Sheffield, Chairman's Address, K. Marshall, 6.30 p.m.

Tues., Oct. 14.—LONDON BRANCH : Royal Institution, Albemarle Street, London, W.1, Presidential Address, " Light and Life," C. C. Smith, 6 p.m.

Wed., Oct. 15.—NORTH LANCASHIRE GROUP : Demonstration Theatre, North Western Electricity Board, 19, Friargate, Preston, Presidential Address, C. C. Smith, 7 p.m.

Mon., Oct. 20.—BATH AND BRISTOL CENTRE : Building Centre, Bristol, " Lighting in Relation to Modern Ceilings and Roofs," D. Phillips, 7 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Oct. 14.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, " Industrial Electronics," V. J. Copley-May, 7.15 p.m.

Wed., Oct. 15.—KENT BRANCH : Kings Head Hotel, High Street, Rochester, Kent, " Ultrasonics in Industry," C. B. Abel-Harry, 7 p.m.

Thurs., Oct. 16.—BLACKBURN BRANCH : White Bull Hotel, Blackburn, " The Work of the Baths Engineer," T. Anderson, 7.30 p.m.

Fri., Oct. 17.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, " Giant Earth Mover Tyres," W. Wortley, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., Oct. 15.—SOUTHAMPTON SECTION : Technical College, St. Mary's Street, Southampton, " Die-Casting," H. J. Sharp, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Tues., Oct. 14.—Memorial Building, 76, Mark Lane, London, E.C.3, " An Investigation into the Optimum Machinery Installation for a Large Steam Turbine Tanker," A. D. Bonny, 5.30 p.m.

Mon., Oct. 20.—WEST OF ENGLAND SECTION : Grand Hotel, Bristol, " Metal Spraying and Synthetic Rubber Coating for the Prevention of Corrosion," J. H. Payne, 7.30 p.m.

INSTITUTE OF NAVIGATION

Wed., Oct. 15.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, Annual General Meeting ; Presidential Address, " Automation in Marine Navigation," F. J. Wylie, 3 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

To-day, Oct. 10.—SOUTH WALES CENTRE : South Wales Institute of Engineers, Park Place, Cardiff, " The Development of Automatic Transmission for Commercial Vehicles," R. B. Robinson, 7 p.m.

Mon., Oct. 13.—EAST REGIONAL CENTRE : Council Chamber, Houldsworth Hall, 90, Deansgate, Manchester, " Brakes and Brake Linings," N. Carpenter, 7.30 p.m.

Tues., Oct. 14.—MIDLANDS CENTRE : Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, Talk and Discussion on " Road Safety," 7.15 p.m. ★ SOUTH WESTERN GROUP : Duke of Cornwall Hotel, Plymouth, " Some Considerations Affecting the Selection and Use of Fuels and Lubricants for Road Transport," R. D. Owen, 7.30 p.m.

Thurs., Oct. 16.—METROPOLITAN AREA : Royal Society of Arts, John Adam Street, London, W.C.2, Annual General Meeting; " Summer and Winter Protection Against Corrosion in Engine Water-Cooling Systems," L. J. Cotton, 6.30 p.m. ★ YORKSHIRE CENTRE : Great Northern Hotel, Wellington Street, Leeds, 1, " The Free Piston Gasifyer with Special Reference to Vehicle Application," F. J. Wallace, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Oct. 14.—NORTH WESTERN BRANCH : Chemical Engineering Building, Manchester College of Science and Technology, Jackson Street, Manchester, " Mass Transfer and Diffusion Phenomena in a Rotary Concentric-Cylinder Distillation Column," N. MacLeod, 6.30 p.m.

Sat., Oct. 18.—MIDLANDS BRANCH : Technical College, Derby, " Flow Patterns in the Hydraulic Cyclone and their Interpretation in Terms of Performance," D. Bradley and D. J. Pulling, 3 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Oct. 14.—Great George Street, Westminster, London, S.W.1, " The Garry and Moriston Hydro-Electric Schemes," C. M. Roberts, E. B. Wilson, J. H. Thornton and H. Headland, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Oct. 10.—NORTH STAFFORDSHIRE SUB-CENTRE : Duncan Hall, Stone, Chairman's Address, R. W. Palmer, 7 p.m. ★ SOUTHERN CENTRE : Southern Electricity Board's Showrooms, Newport, Isle of Wight, " Survey of Recent Developments in Marine Radar," A. L. P. Milwright, 6.30 p.m.

Mon., Oct. 13.—INFORMAL MEETING : Savoy Place, London, W.C.2, Discussion on " The Rationalisation of the Avenues of Higher Education for Electrical Engineers," 5.30 p.m. ★ NORTH EASTERN CENTRE : Neville Hall, Westgate Road, Newcastle upon Tyne, Chairman's Address, A. T. Crawford, 6.15 p.m. ★ SOUTH MIDLAND CENTRE : Malvern Winter Gardens, Malvern, " Radio Observations on Artificial Satellites," J. A. Ratcliffe, 7.30 p.m. ★ SOUTH MIDLAND SUPPLY AND UTILISATION GROUP : College of Technology, Birmingham, " D.C. Winder Drives using Mercury/Arc Rectifier Inverters," L. Abram, J. P. McBreen and J. Sherlock, 6 p.m. ★ WESTERN CENTRE : Electricity House, Carlton Avenue, Bristol, Chairman's Address, R. W. Steel, 6 p.m. ★ READING DISTRICT : George Hotel, King Street, Reading, " Fundamentals of Fuel Efficiency in the Generation of Electricity," R. Wood, 7.15 p.m.

Tues., Oct. 14.—MEASUREMENT AND CONTROL SECTION : Savoy Place, London, W.C.2, Chairman's Address, " The Scope of the Measurement and Control Section," J. K. Webb, 5.30 p.m. ★ NORTH-WESTERN UTILISATION GROUP : Engineers' Club, Albert Square, Manchester, " Electrification of the U.K.A.E.A. Industrial Group Factories," J. W. Binns and W. J. Outram, 6.15 p.m. ★ NORTHERN IRELAND CENTRE : Civil Engineering Department, Queen's University, Belfast, Chairman's Address, " The Insulator Surface," D. S. McIlhagger, 6.30 p.m.

Wed., Oct. 15.—LONDON GRADUATE AND STUDENT SECTION : Savoy Place, London, W.C.2, Chairman's Address, " Electrical Power Generation and its Future in Southern England," J. F. Outram, 6.30 p.m. ★ SHEFFIELD SUB-CENTRE : Grand Hotel, Sheffield, Chairman's Address, " The Origin and Growth of Electronics," F. A. Benson, 6.30 p.m. ★ SOUTH-WEST SCOTLAND SUB-CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, Chairman's Address, R. J. Rennie, 7 p.m. ★ SOUTHERN CENTRE : College of Technology, Anglesea Road, Portsmouth, " Re-Heat Practice in Power Stations," F. H. S. Brown and G. W. H. Dore, 6.30 p.m.

Thurs., Oct. 16.—UTILIZATION SECTION : Savoy Place, London, W.C.2, Chairman's Address, " Installation Engineering," R. A. Marryat, 5.30 p.m. ★ NORTH MIDLAND CENTRE : Yorkshire Electricity Board Offices, Ferensway, Hull, " A Test Bed for D.C. Machines and Control Gear," J. Holgate and E. Rawnsley, 6.30 p.m. ★ NORTH SCOTLAND SUB-CENTRE : Electrical Engineering Department, Queen's College, Dundee, Chairman's Address, R. J. Rennie, 7 p.m. ★ SOUTH-WESTERN SUB-CENTRE, S.W.E.B. Showrooms, New George Street, Plymouth, Chairman's Address, W. W. Ash, 3 p.m. ★ IRISH BRANCH : Physical Laboratory, Trinity College, Dublin, Chairman's Address, R. L. S. McDowell, 6 p.m.

Fri., Oct. 17.—NORTH SCOTLAND SUB-CENTRE : Robert Gordon's Technical College, Aberdeen, Chairman's Address, R. J. Rennie, 7.30 p.m.

Sat., Oct. 18.—LONDON GRADUATE AND STUDENT SECTION : Visit to Metropolitan Water Board, Ashford Common, Staines, 2.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Oct. 13.—NORTH-EAST BRANCH : Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, 1, " Water Turbine Driven Generators," G. R. Small, 7.15 p.m.

Wed., Oct. 15.—YORKSHIRE BRANCH : Visit to Forgrove Machinery Company, Ltd., Dewsbury Road, Leeds, 11, 7.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, Oct. 10.—NORTH-EAST BRANCH : The University Durham, " Geology and Roadstones of Northumberland and Durham," K. C. Dunham, 7 p.m.

Tues., Oct. 14.—SOUTH WALES BRANCH : National Museum of Wales, Cardiff, "Geology for Highway Engineers," Dr. North.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Oct. 15.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, " The Mechanics of the Train in the Service of Railway Operation," S. O. Ell, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Thurs., Oct. 16.—COVENTRY GRADUATES' SECTION : Grosvenor Room, Leofric Hotel, Coventry, Senior Member's Address, W. M. Heynes, 7.30 p.m.

Fri., Oct. 17.—ORDINARY MEETING : 1, Birdcage Walk, Westminster, London, S.W.1, Presidential Address, " The Mechanical Engineering of Aircraft Mechanisms," Air Marshal Sir Owen Jones, 6 p.m.

Mon., Oct. 20.—DERBY A.D. CENTRE : Railway College, London Road, Derby, " Basis of Railway Signalling," G. Holt, 7.15 p.m. ★ SCOTTISH A.D. CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, Chairman's Address, 7.30 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., Oct. 16.—Geological Society, Burlington House, Piccadilly, London, W.1, " Sinking No. 2 Shaft, Harmony Gold Mining Company, Ltd., Orange Free State," S. C. Newman ; " The Micropanner—An Apparatus for the Gravity Concentration of Small Quantities of Materials," L. D. Muller, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Sat., Oct. 11.—HALIFAX AND HUDDERSFIELD GRADUATE SECTION : Visit to the Mersey Tunnel Works and Port Radar Station, Gladstone Dock, 10.15 a.m.

Mon., Oct. 13.—LEEDS SECTION : Hotel Metropole, Leeds, " The Handling of Waste Materials in a Medium-Sized Factory," W. M. Cunningham ; " Materials Handling in a Bakery," K. L. Horn, and " Bulk Handling," J. Keightley, 7 p.m. ★ STOKE-ON-TRENT SECTION : Grand Hotel, Hanley, Stoke-on-Trent, " Pattern Making in Plastics," A. G. King, 7.30 p.m. ★ NEWCASTLE UPON TYNE SECTION : Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, " Sintered Oxides as Cutting Tools," H. Eckersley, 7 p.m.

Tues., Oct. 14.—DONCASTER SECTION : Technical College Hall, Doncaster, " Human Resistance to Change and the Place of Discussion Groups in Changing Attitudes," E. W. Hughes, 7 p.m. ★ BIRMINGHAM GRADUATE SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, " Theory and Practice of Spark Machining," E. Foster, 7 p.m.

Wed., Oct. 15.—HALIFAX AND HUDDERSFIELD SECTION : Percival Whitley Technical College, Francis Street, Halifax, " We Build the Jig Mill," R. C. Fenton, 7.30 p.m. ★ BIRMINGHAM SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, " Productivity—The Production Engineer —and the European Common Market," M. Halls, 7.30 p.m. ★ WOLVERHAMPTON SENIOR AND GRADUATE SECTION : Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton, " Recording and Accounting," 7 p.m. ★ PETERBOROUGH SECTION : Conference Room, Peterscouri, Peterborough, " Automatic Linking Devices," J. B. Jay, 7.30 p.m. ★ PRESTON SECTION : Harris College of Further Education, Corporation Street, Preston, " A New Approach to Production Control," J. L. Burbidge, 7.30 p.m. ★ LONDON GRADUATE SECTION : 10, Chesterfield Street, London, W.1, "The Development and Applications of P.T.F.E.," E. M. Elliot, 7.15 p.m. ★ WESTERN SECTION : Large Lecture Theatre, The University, Bristol, " Productivity in the European Common Market," Lieut.-General Sir Thomas Hutton, 7.30 p.m. ★ EDINBURGH SECTION : North British Hotel, Princes Street, Edinburgh, " Mechanical Engineering Research Laboratory—Work of the Mechanisms, Engineering Metrology and Noise Control Division," C. Timms, 7.30 p.m.

Thurs., Oct. 16.—SOUTHAMPTON SECTION : Polygon Hotel, Southampton, Open Forum, " Electronics for Engineering," 7.15 p.m.

Fri., Oct. 17.—IPSWICH AND COLCHESTER SECTION : Britannia Works Canteen, Davey Paxman and Co., Ltd., Colchester, " Building Merchant Ships in a Modern Shipyard," J. Leather, 7.30 p.m.

Mon., Oct. 20.—COVENTRY SECTION : Craven Arms, High Street, Coventry, " Automatically Controlled Machine Tools," J. A. Stokes, 7.15 p.m. ★ DERBY SECTION : Louis Room, St. James Restaurant, St. James Street, Derby, " Lens—Their Manufacture and Uses," E. Atkinson, 7 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Mon., Oct. 13.—SCOTTISH BRANCH : Institution of Engineers and Shipbuilders, Glasgow, Chairman's Address, W. Heigh, 7 p.m.

Tues., Oct. 14.—LONDON GRADUATES' AND STUDENTS' SECTION : 11, Upper Belgrave Street, London, S.W.1, " Design of Cities," Johnson Marshall, 6.30 p.m.

Wed., Oct. 15.—YORKSHIRE BRANCH : Metropole Hotel, Leeds, Chairman's Address, R. H. Evans, 6.30 p.m.

Thurs., Oct. 16.—YORKSHIRE BRANCH : Royal Victoria Hotel, Sheffield, Chairman's Address, R. H. Evans, 6.30 p.m.

Fri., Oct. 17.—WESTERN COUNTIES BRANCH : University Engineering Laboratories, Bristol, Chairman's Address, " Modular Co-ordination in Building," P. Gardiner, 6 p.m.

IRON AND STEEL INSTITUTE

Tues. to Thurs., Oct. 14 *to* 16.—Thirty-seventh Meeting of the Iron and Steel Engineers Group, Blossoms Hotel, Chester, 4.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Oct. 10.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, " Photography in Industry," C. Newland, 7 p.m.

Mon., Oct. 13.—SHEFFIELD AND DISTRICT SECTION : Livesey Clegg House, 44, Union Street, Sheffield, 1, Annual General Meeting ; Chairman's Address, " A.C. Motor Winding," R. A. Reeve, 7.30 p.m.

Fri., Oct. 17.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, " Radio Measurements on the Russian Earth Satellites," J. Heywood, 7 p.m.

PLASTICS INSTITUTE

Tues., Oct. 14.—LONDON SECTION : Wellcome Building, 183–193, Euston Road, London, N.W.1, Open Forum, " Thermoplastic Pipes," 6.30 p.m.

Wed., Oct. 15.—NORTH-EASTERN SECTION : Eldon Grill, Grey Street, Newcastle, " The Use of Paper in the Plastics Industry," D. A. Knight, 7 p.m.

Thurs., Oct. 16.—NORTH-WESTERN SECTION : Evening Visit to the Metal Box Company, Ltd., Westhoughton.

Fri., Oct. 17.—MIDLANDS SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, 3, " Polypropylene," F. Ranalli and G. Crespi, 6.30 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., Oct. 14.—MIDLAND COUNTIES BRANCH : Birmingham and Midland Institute, Paradise Street, Birmingham, Film Evening, 6 p.m.

Wed., Oct. 15.—11, Upper Belgrave Street, London, S.W.1, " The Architectural Expression of Structural Concrete," W. A. Gibbon, 6 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Oct. 13.—VALUATION AND RATING GENERAL MEETING : 12, Great George Street, Westminster, London, S.W.1, " Valuation of Commercial Properties," W. N. D. Lang, 5.45 p.m.

Wed., Oct. 15.—QUANTITY SURVEYORS' GENERAL MEETING : 12, Great George Street, Westminster, London, S.W.1, " Quantity Surveying in the U.S.A.," R. Stevens, 6 p.m.

ROYAL METEOROLOGICAL SOCIETY

Wed., Oct. 15.—49, Cromwell Road, London, S.W.7, " The Movement of Precipitation Belts as Observed by Radar,' W. G. Harper and J. G. D. Beimers ; " Modification of the Structure of a Tropical Cyclone on Traversing a High Plateau," N. P. Sellick, 5 p.m.

ROYAL SOCIETY OF HEALTH

Thurs., Oct. 16.—LONDON SESSIONAL MEETING : Caxton Hall, Westminster, London, S.W.1, Symposium on " New Trends in Plumbing and Sanitation," 2.30 p.m.

ROYAL STATISTICAL SOCIETY

Tues., Oct. 14.—MERSEYSIDE GROUP : Royal Institute, Colquitt Street, Liverpool, " Operational Research in Industry," K. D. Tocher, 7 p.m.

Thurs., Oct. 16.—BRISTOL GROUP : Library Room, The University, Bristol, 8, " ' Monte Carlo ' for Statisticians," W. N. Jessop, 5.45 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Tues., Oct. 14.—CHEMICAL ENGINEERING GROUP : 14, Belgrave Square, London, S.W.1, " Titanium and its Alloys as Materials of Construction for Chemical Plant," K. W. J. Bowen, 6 p.m.

Thurs., Oct. 16.—ROAD AND BUILDING MATERIALS GROUP : 14, Belgrave Square, London, S.W.1, " Surface Active Agents and Surface Dressing," D. H. Mathews, 6 p.m.

SOCIETY OF ENGINEERS AND METALLURGISTS

Mon., Oct. 20.—The University Building, St. George's Square, Sheffield, " Atmospheric Pollution in the Iron and Steel Industry," J. H. Flux and F. A. Gray, 7.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

To-day, Oct. 10.—MIDLAND SECTION : Regent House, St. Philip's Place, Colmore Row, Birmingham, 3, " Instrumentation in the Oil Industry," A. Cowan, 7 p.m.

Tues., Oct. 14.—MANCHESTER SECTION : " Manchester " Room, Central Library, St. Peter's Square, Manchester, 1, " Accuracy in the Production of Modern Instruments," H. Mathews, 6.30 p.m.

Wed., Oct. 15.—NEWCASTLE SECTION : King's College, Stephenson Buildings, Newcastle upon Tyne, " The Progress of Temperature Measurement in Industry," R. Postle, 7 p.m. ★ TEESSIDE SECTION : Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough, " A Quantitative Approach to Level Control," R. Jackson, 7.30 p.m.

Thurs., Oct. 16.—EAST MIDLAND SECTION : College of Technology and Commerce, The Newarke, Leicester, " Semi-Conductors and their Applications," G. M. Ettinger, 6.30 p.m.

Mon., Oct. 20.—DATA PROCESSING SECTION : Manson House, Portland Place, London, W.1, " A Simple Data Read-Out System," G. D. Tonkin, 6 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

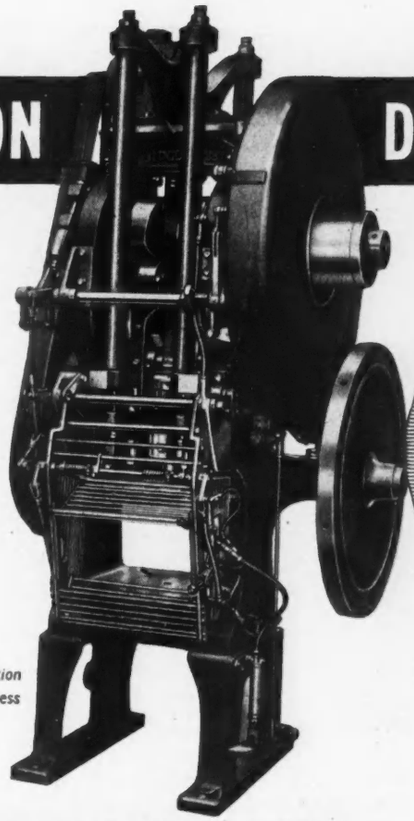
Fri., Oct. 17.—39, Elmbank Crescent, Glasgow, Presidential Address, H. Harris, 6.45 p.m.

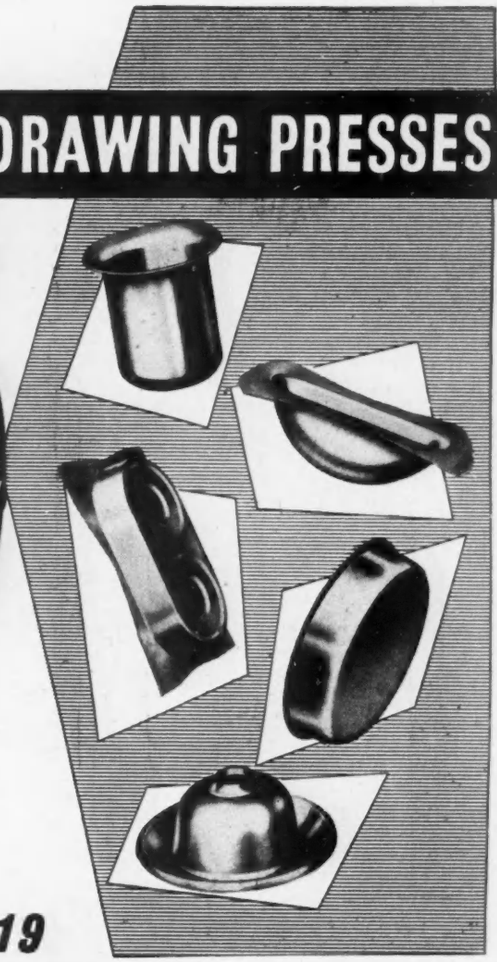
Advanced Engineering Courses

The Application of Work Study. UNIVERSITY INSTITUTE FOR ENGINEERING PRODUCTION, " Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. Residential executive course from Monday, October 13, to Friday, October 24. Application should be made to Dr. N. A. Dudley, Director of the Institute for Engineering Production. Fee 50 guineas.

Fundamental Nuclear Physics for Engineers. THE COLLEGE OF TECHNOLOGY, Cabot House, Ashley Down, Bristol, 7. The course is designed for engineers, physicists and industrial executives with responsibility particularly in the field of the generation of power from nuclear energy and is intended to give a basis of underlying theory in nuclear physics and its applications. To-day and Saturday, October 10 and 11. Fee (non-residential), 1 guinea.

DOUBLE ACTION DRAWING PRESSES





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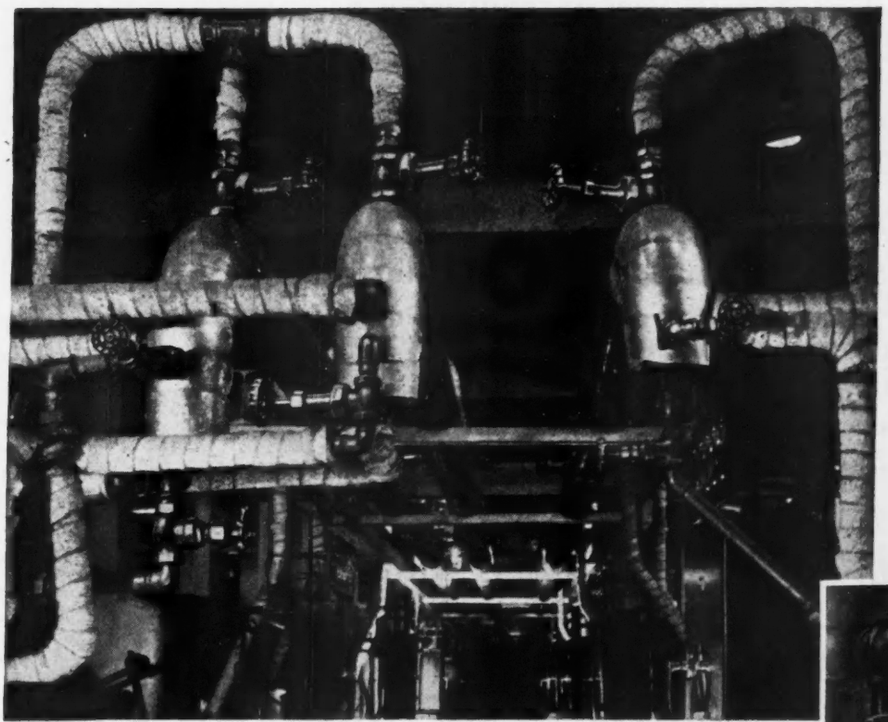
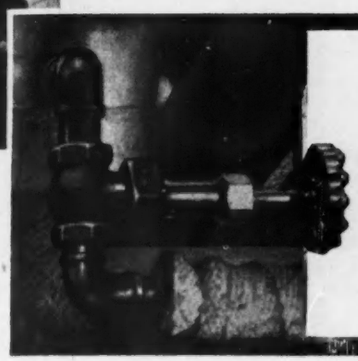


D24 A section of the Bag-o-matic Tyre Curing plant featuring Crane No. D186 valves.
(Photograph by permission of The Firestone Tyre and Rubber Co. Ltd.)

Once again, valves by Crane

At the Firestone Tyre & Rubber Co. Ltd., their latest Tyre Vulcanizing Press is almost entirely automatic. A plant of this type must not be delayed due to valve failure, and naturally the Firestone engineers selected Crane valves to ensure a high standard of service and dependability. Their choice for this plant was the Crane No. D186 Bronze Gate Valve. Important features of this valve are that it has a union bonnet, nickel alloy wedge disc and stainless steel seats. The confidence placed by engineers in Crane products is emphasised by this association with Firestone—for here Crane valves are playing an important part in one of the latest examples towards automation in industry.



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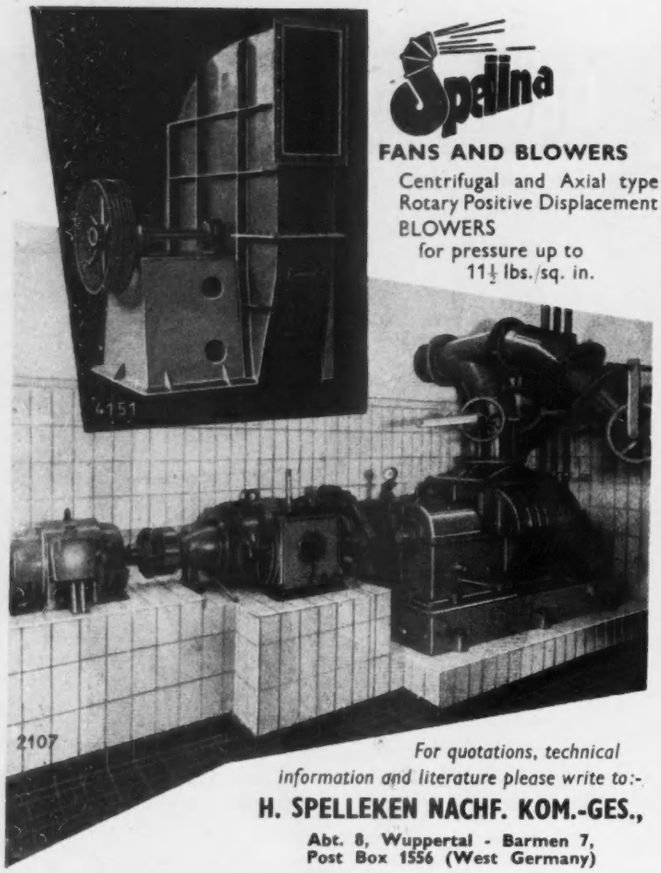

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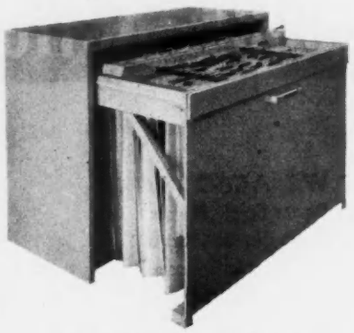

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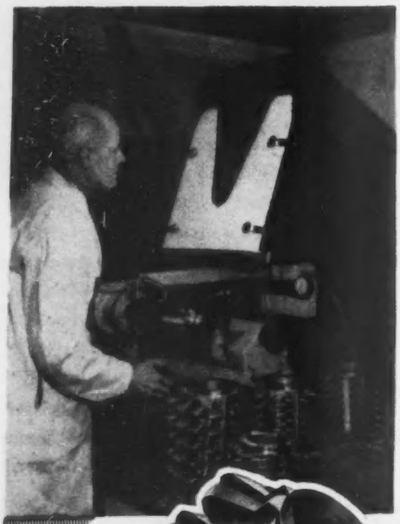

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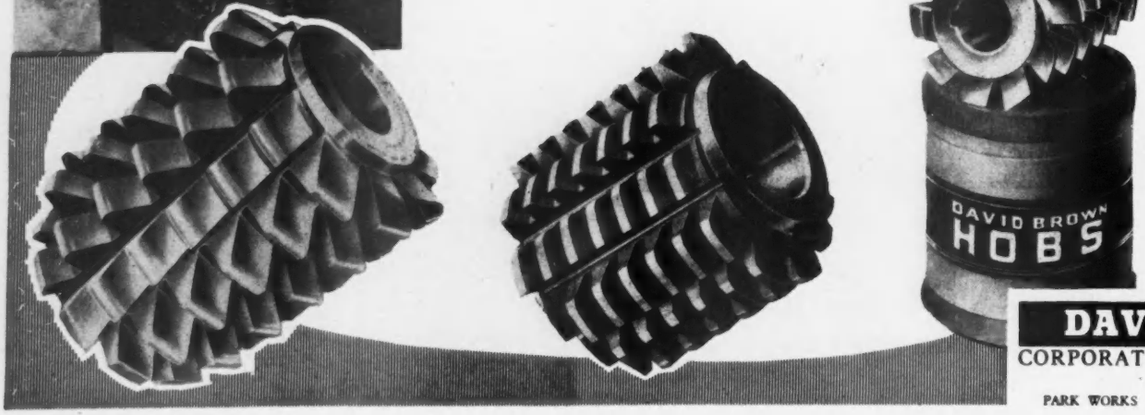

WRITE TO-DAY FOR LEAFLET E.313.9.

THE
DAVID BROWN
CORPORATION (SALES) LIMITED
TOOL DIVISION
PARK WORKS HUDDERSFIELD

Corrugated 'Perspex' roof lighting installed in the works of Mitchell, Russell & Co., Bonnybridge. Photography by arrangement with Newton, Robertson & Co. Ltd., Glasgow.

In this foundry workshop they cash in on daylight

IN THE WORKS of Mitchell, Russell & Co. at Bonnybridge they make the most of the daylight. Roof lighting by Corrugated 'Perspex' acrylic sheet not only saves on artificial light; it also gives good working conditions that mean higher output, better quality work, and less scrap.

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It's as clear as daylight—it must be

CORRUGATED 'PERSPEX'

'Perspex' is the registered trade mark for the acrylic sheet manufactured by I.C.I.

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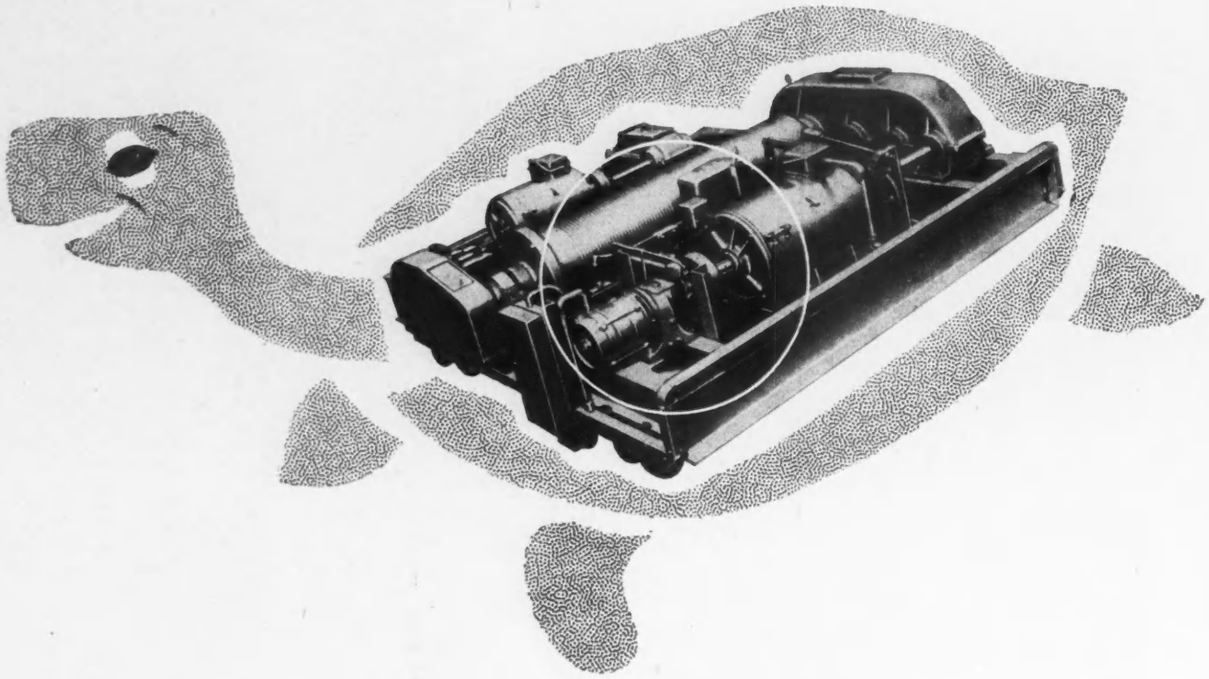
ICI

slowly but surely . . .



Slomax Creep-Speed Control

This system was developed to meet the need for a controlled creeping speed for all motions of cranes on A.C. supply where precise slow-speeds are required.

The success of this well-tried system, proved under arduous conditions, lies in its extreme simplicity.

The device is entirely automatic and fool-proof.

The main motor is not energised when the creeping speed is in operation.

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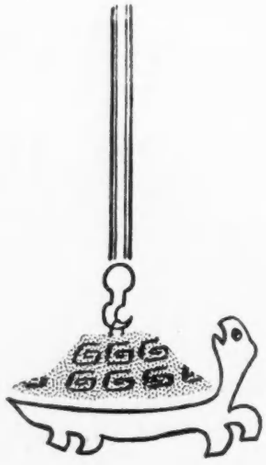
A further advantage is that where precise creeping speeds are required for specialised operations, the Slomax control will ensure a predetermined creeping speed, irrespective of the load on the hook.



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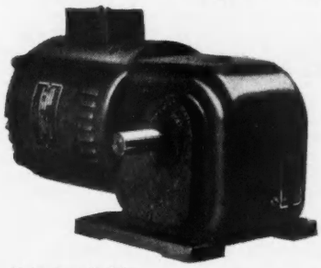
right-angled geared motors

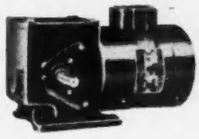


NECO right angle drive geared motors are units of compact design especially suitable for applications where space is limited. There is a wide range of output speeds and gearing is by worm, or worm and spur reduction, according to type of unit.

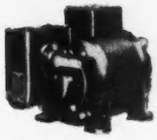
Patent applied for

NEW TYPE DR GEARED MOTOR

Type DR geared motors have ball bearing oil-immersed worm and wheel, with additional spur reductions. Motors of 1/6, 1/4, 1/3 or 1/2 h.p., for 3 phase, single phase or D.C. supplies, are fitted to the one-piece cast-iron gearbox. Final shaft speeds are from 15.6 r.p.m. to 305 r.p.m. Speeds down to 0.05 r.p.m. with a maximum torque of 100 lb.-ft. are available.



TYPE SW 1/8 h.p. motors, 3 phase, single phase, or D.C., final shaft speeds between 270 r.p.m. and 0.055 r.p.m. Maximum output torque is 25 lb.-ft. below 14.8 r.p.m.



TYPE W 1/8, 1/4 or 1/3 h.p., 3 phase, single phase, or D.C. Final shaft speeds from 270 r.p.m. down to 90 or 45 r.p.m. according to output.

NECO TRADE MARK

geared motors

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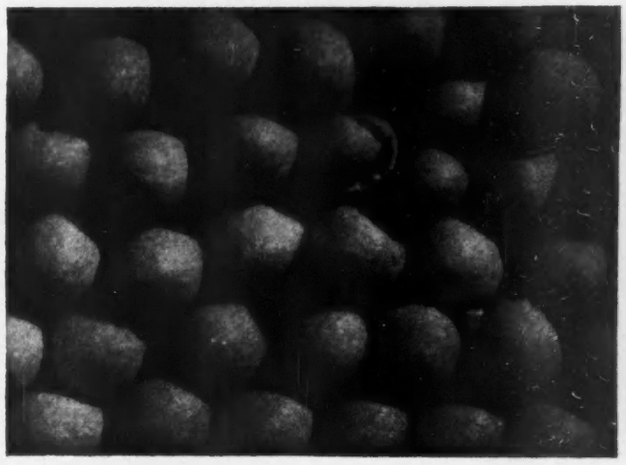

that this picture shows a clutch of turtles' eggs? Maybe you're not too sure.*

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* (*The "eggs" are really the heads of matches.*)

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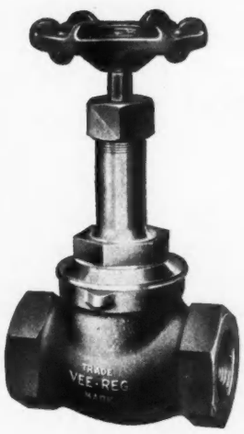

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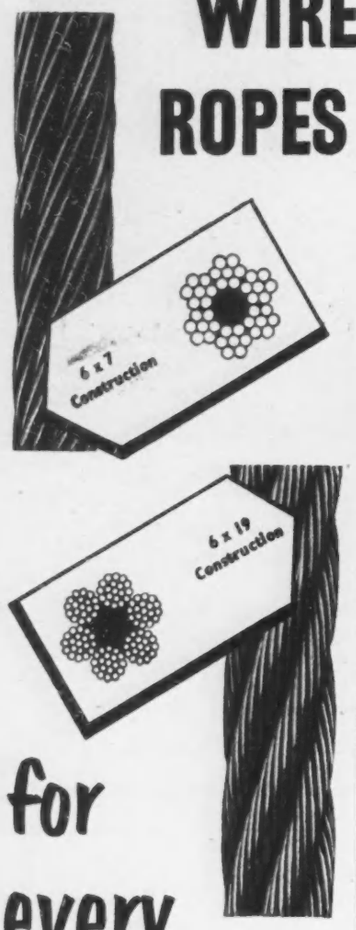

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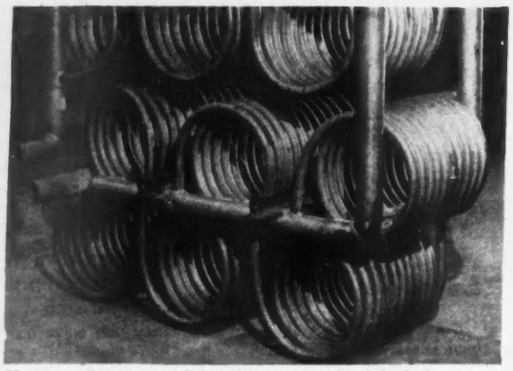
When rapid heat transfer is an important consideration in selecting a metal for processing equipment, nickel, Monel or Inconel can often provide the thermal conductivity needed for economic operation.

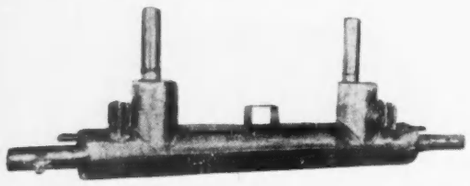
'AT' Nickel kettles, for instance, compare favourably with copper kettles and are superior to those made of other metals having comparable corrosion-resistance.



Heating coils of pure nickel used in a vegetable oil deodorizer.

The ability of 'AT' Nickel to transfer heat rapidly, plus its strength, toughness and resistance to corrosion make it useful for evaporators, coils and heat exchangers. Both Monel and Inconel have useful thermal conductivity and are often used for heat exchangers, condensers and tanks where corrosion-resistance is important.

Thermal conductivity, in itself, is not necessarily a true indication of the heat transfer rate of a metal in service, since this is often affected by gas and liquid films, and especially by corrosion deposits.



To transfer heat from liquid sodium to a liquid sodium-potassium mixture, this type of heat exchanger is made of Low-Carbon 'AT' Nickel. Nickel is used because it resists corrosion by the liquid metals and because its high heat-transfer rate makes it possible to use smaller units.

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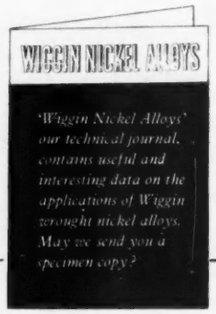
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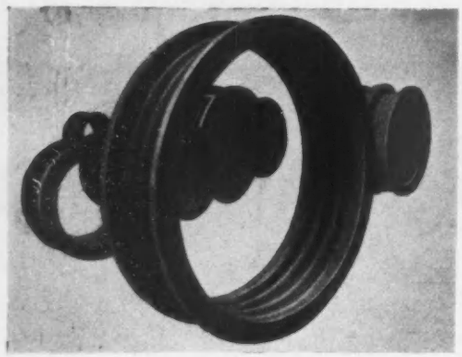
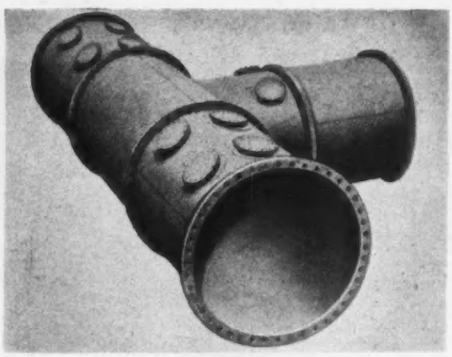
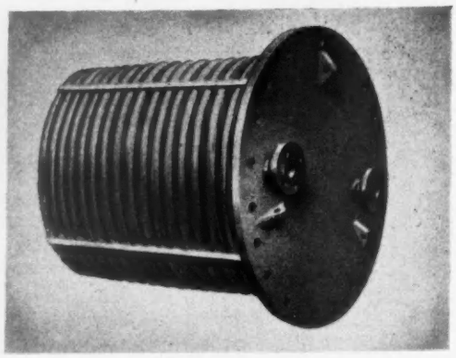

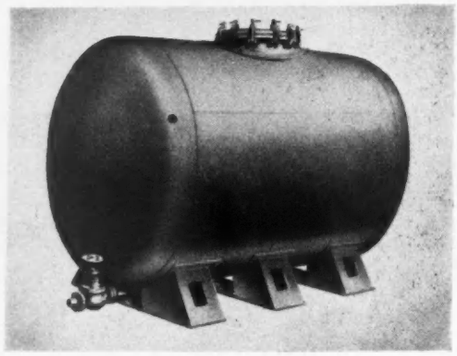

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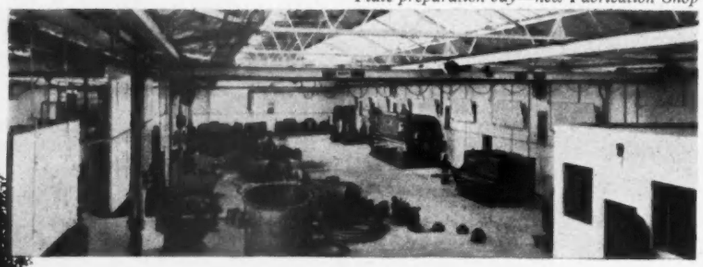

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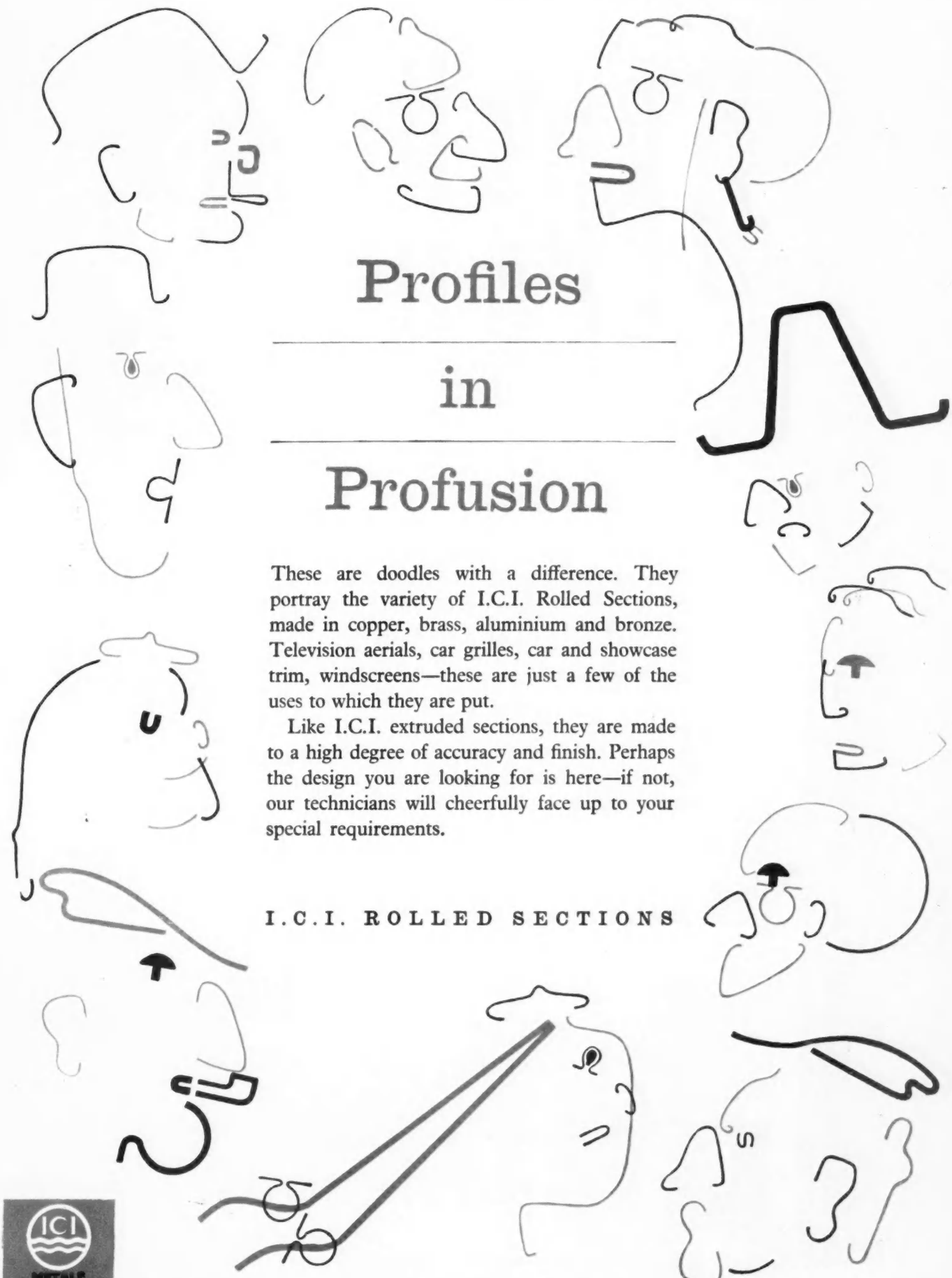

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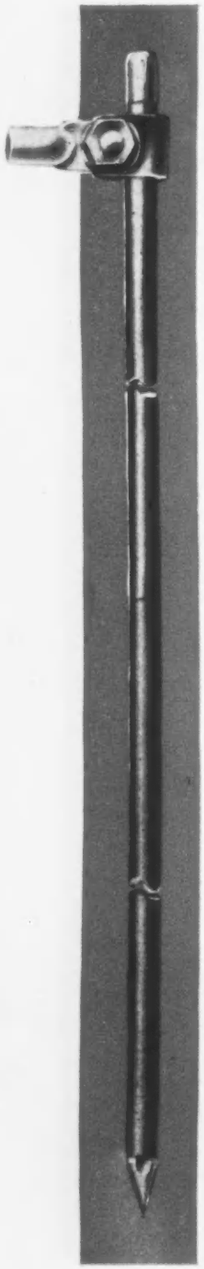

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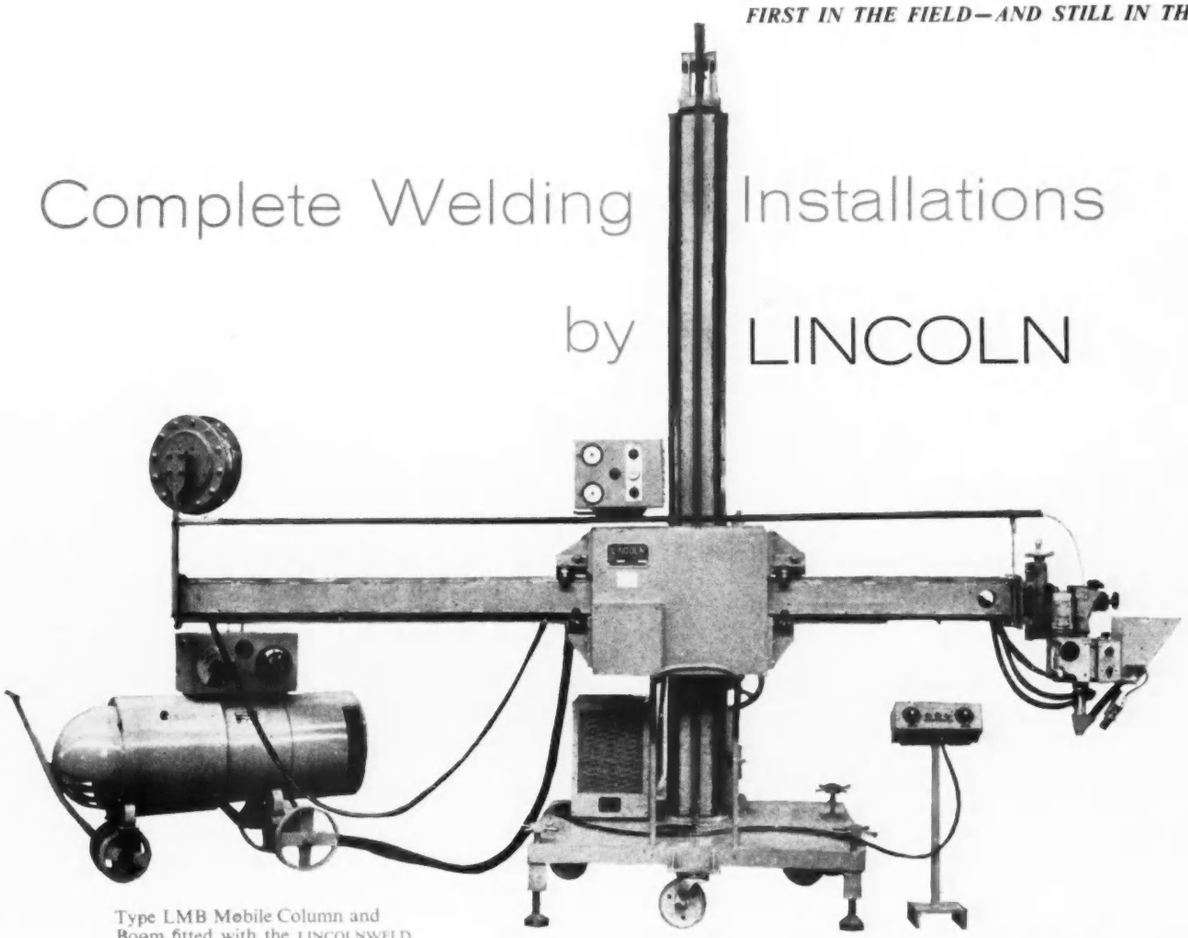

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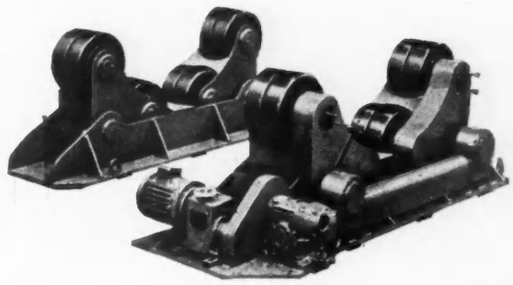

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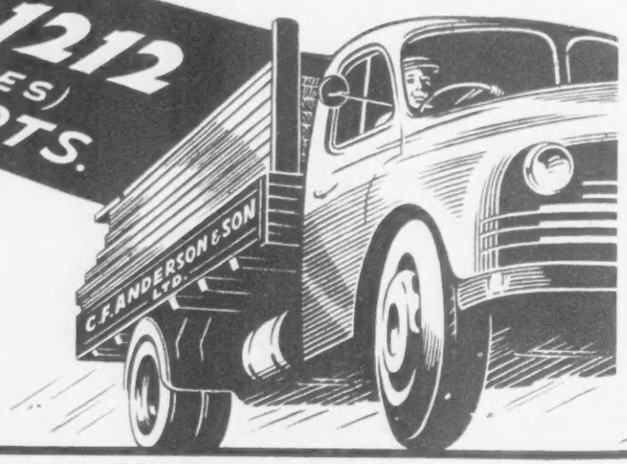

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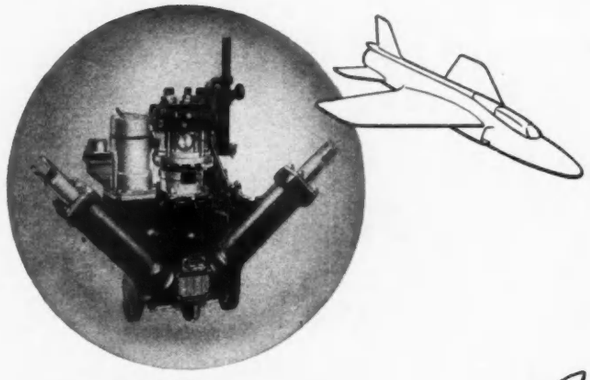

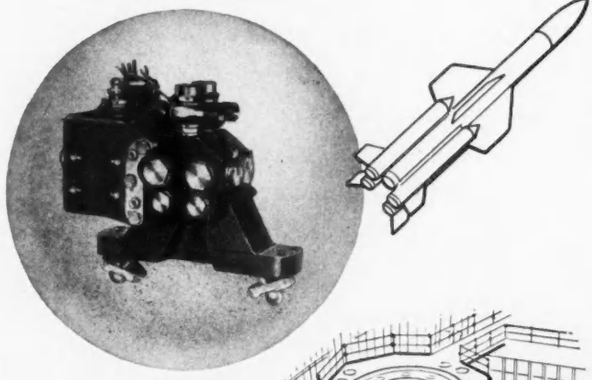

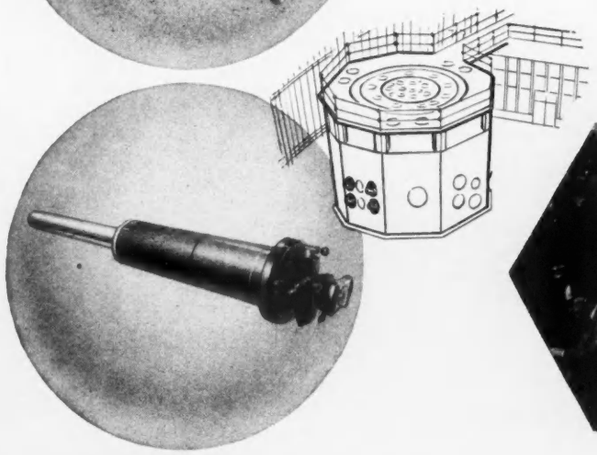

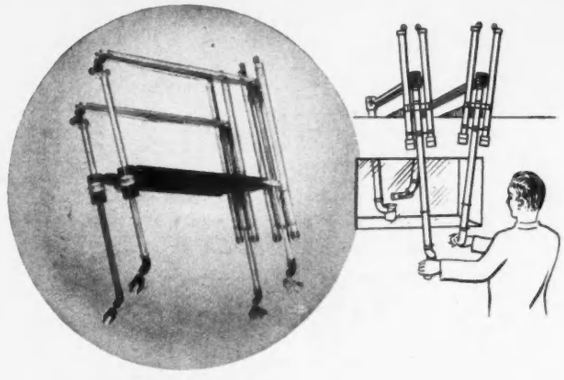

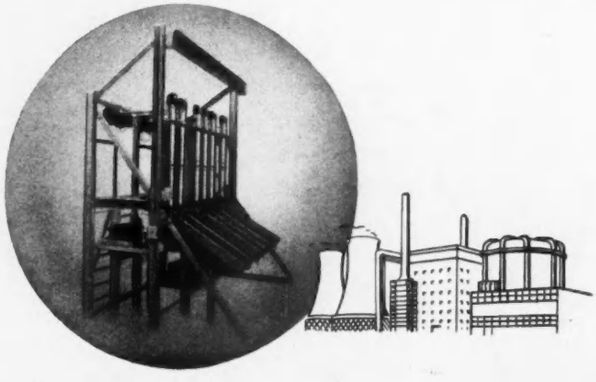

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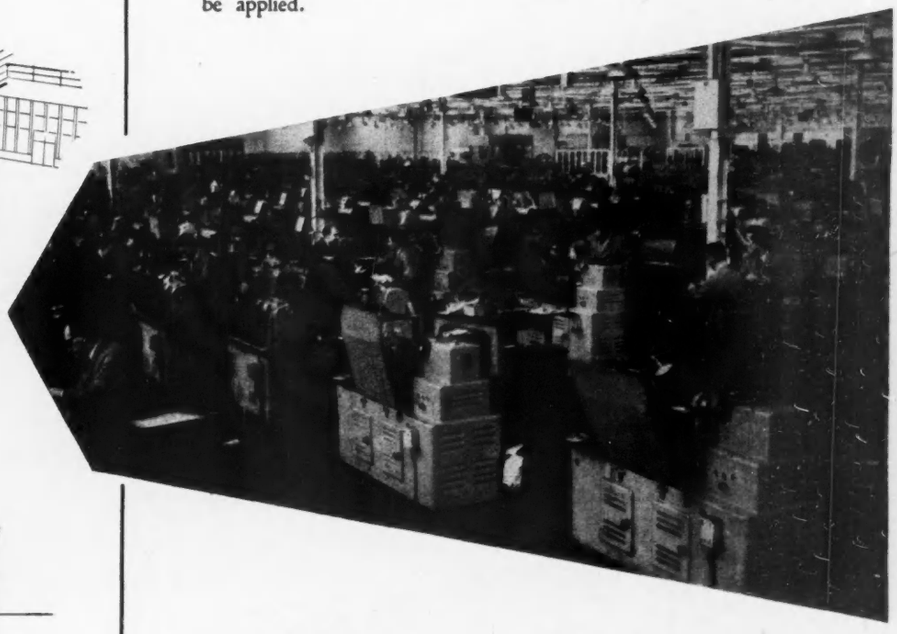

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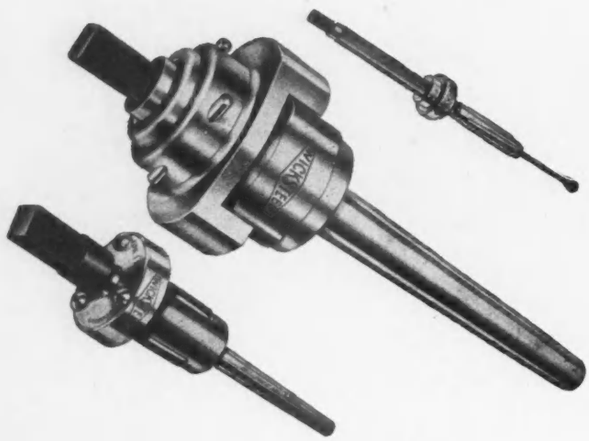

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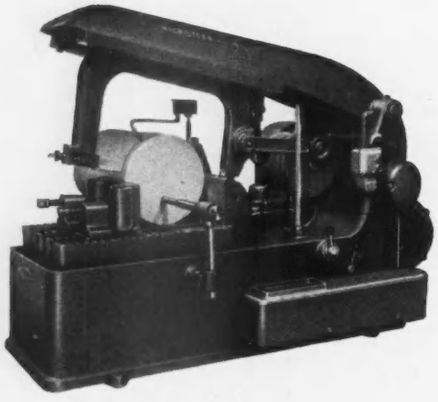

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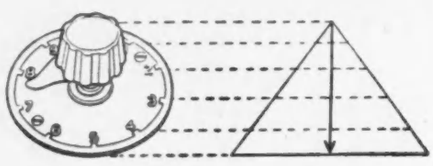

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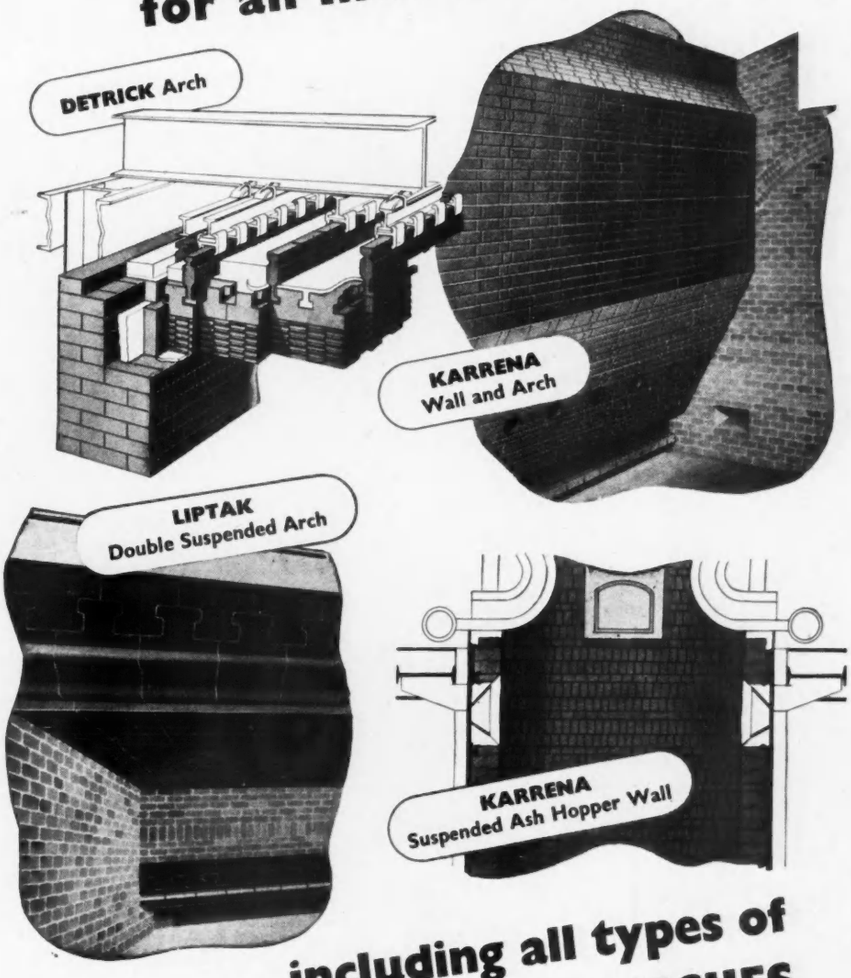

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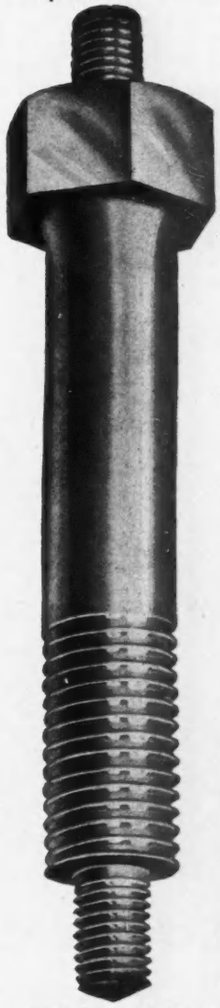

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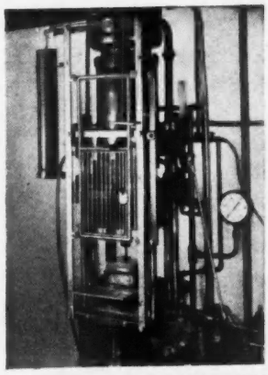

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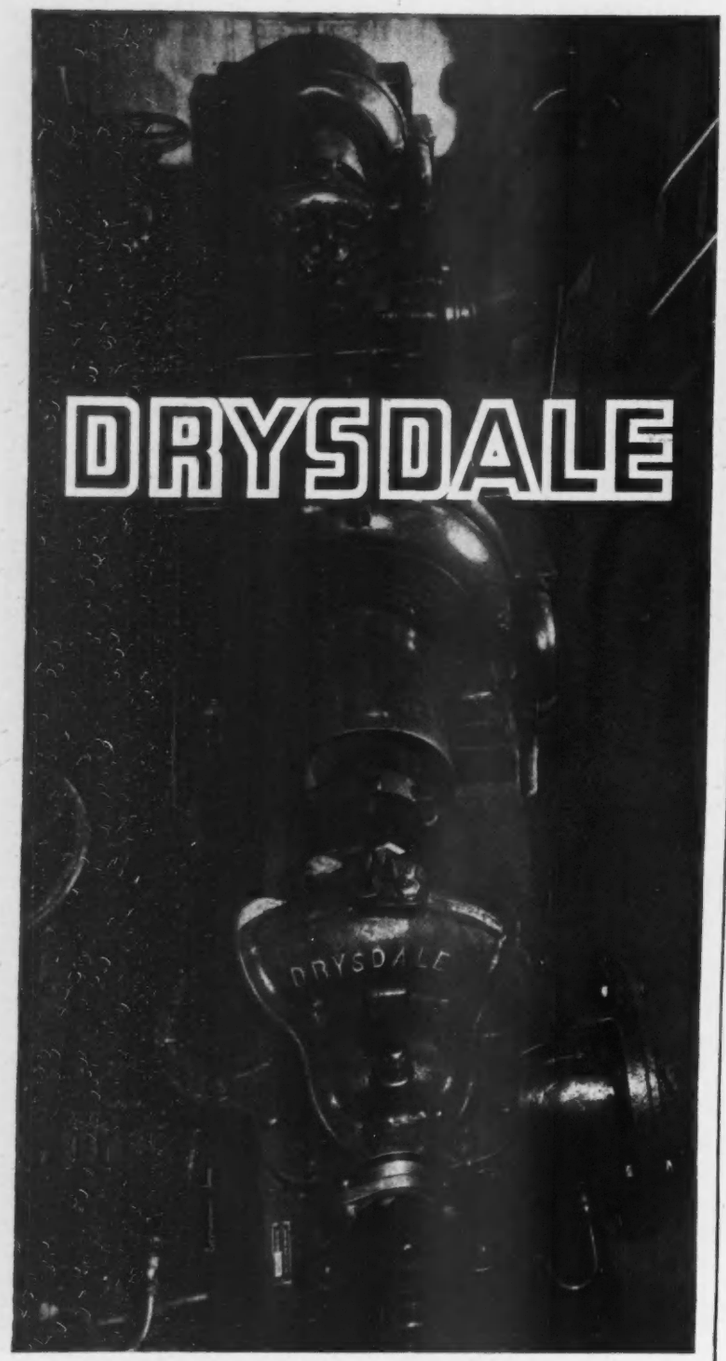

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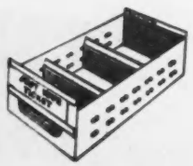

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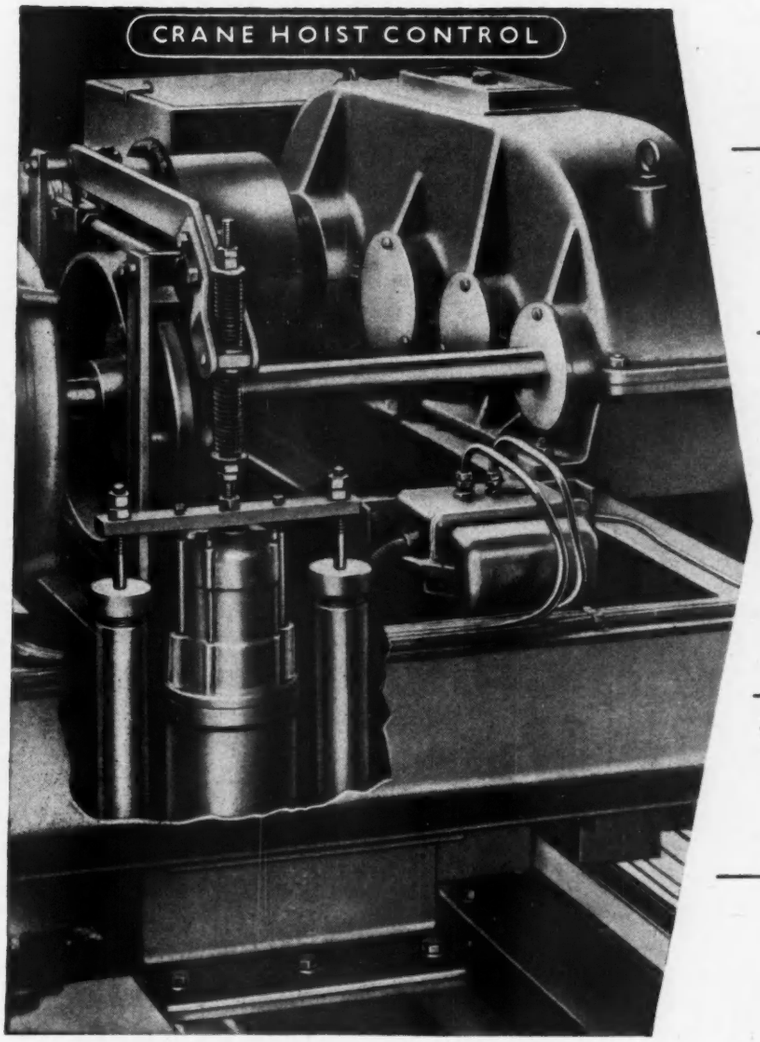

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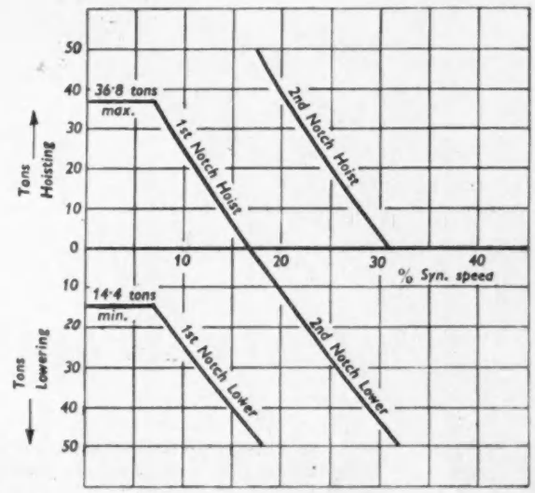
3 The speed of thrustor motor drops and the brake is gradually applied until Load Torque + Braking Torque = Motor Torque at a stable creep speed.

For further details, send for descriptive leaflets 12/4e-1



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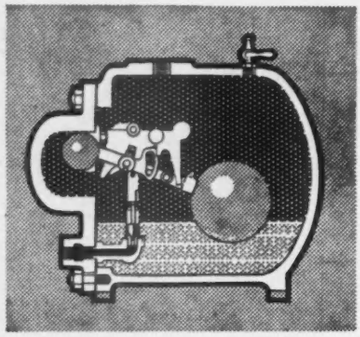

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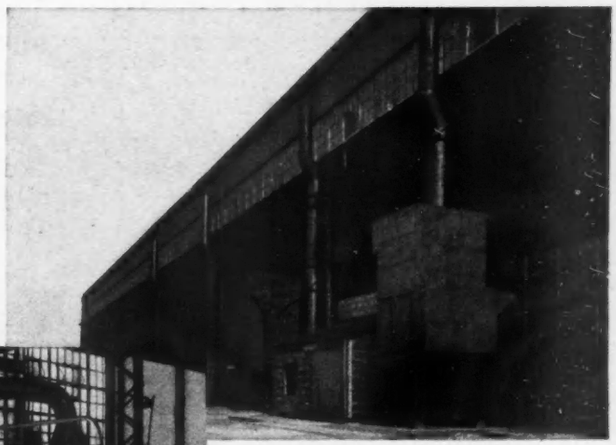

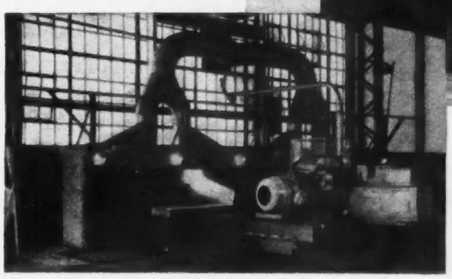

DUST EXTRACTION
Swing grinder dust exhaust plant with textile filters, equipped by Keith Blackman. Photographs by courtesy of Shepcote Lane Rolling Mills Ltd., Sheffield.

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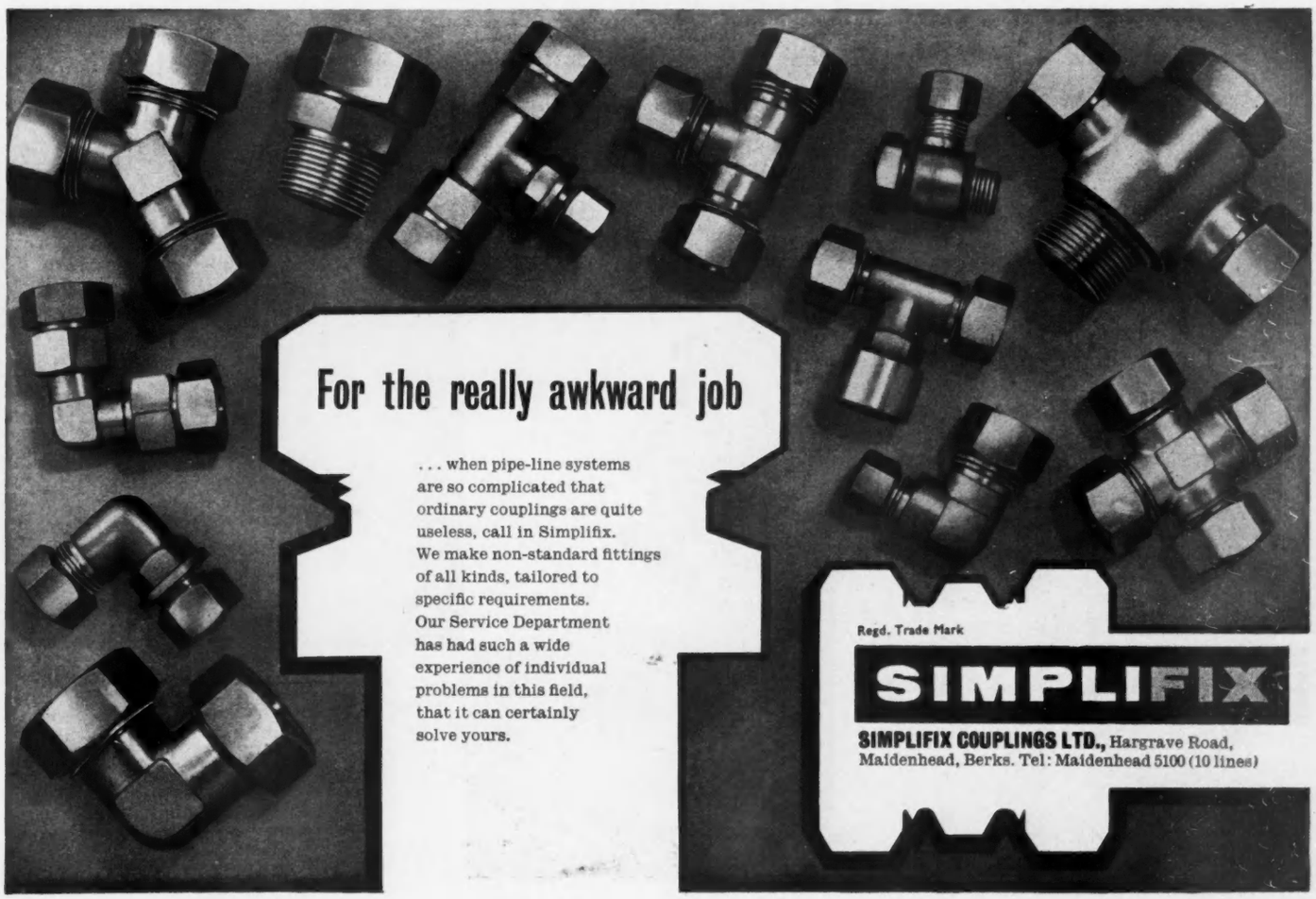

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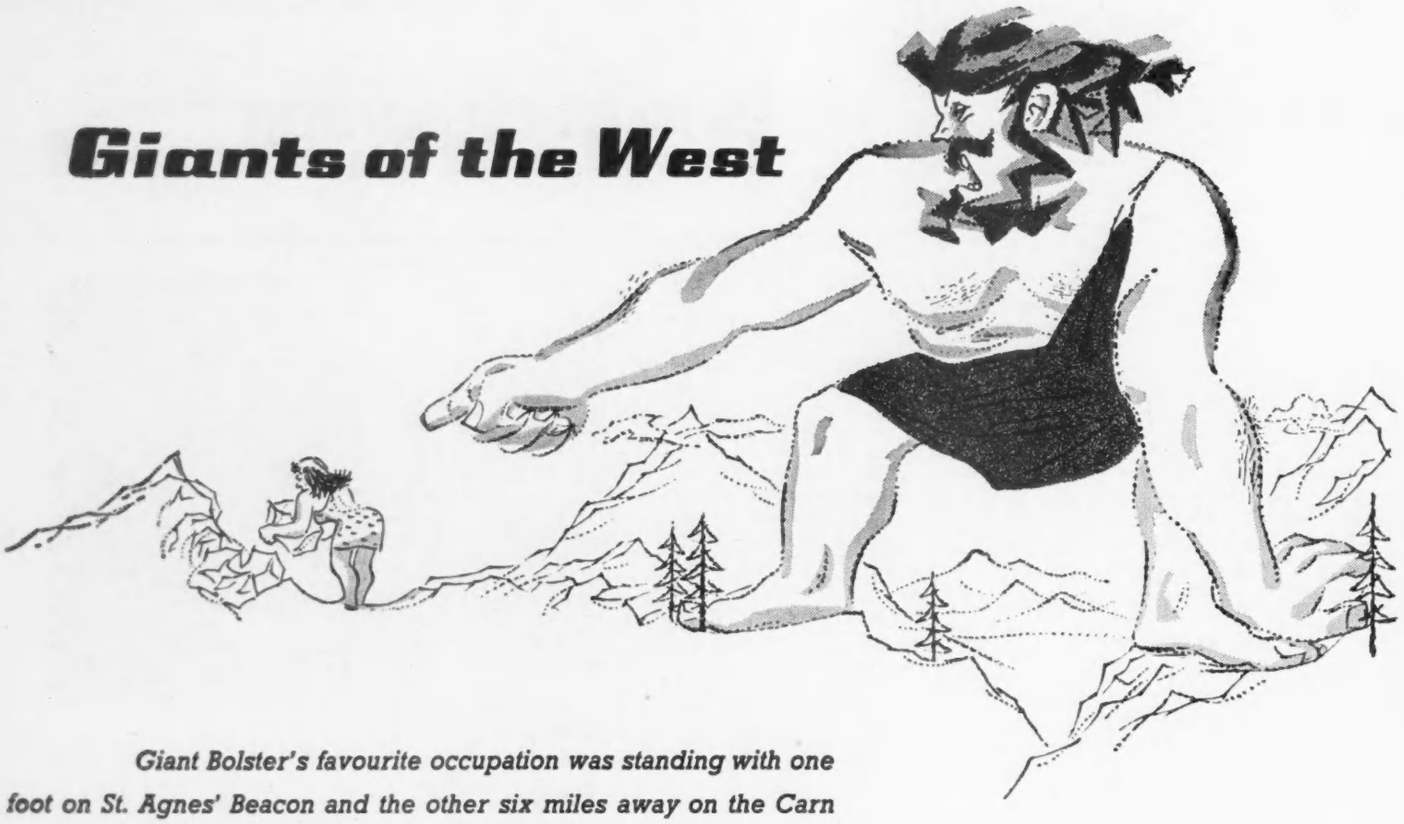
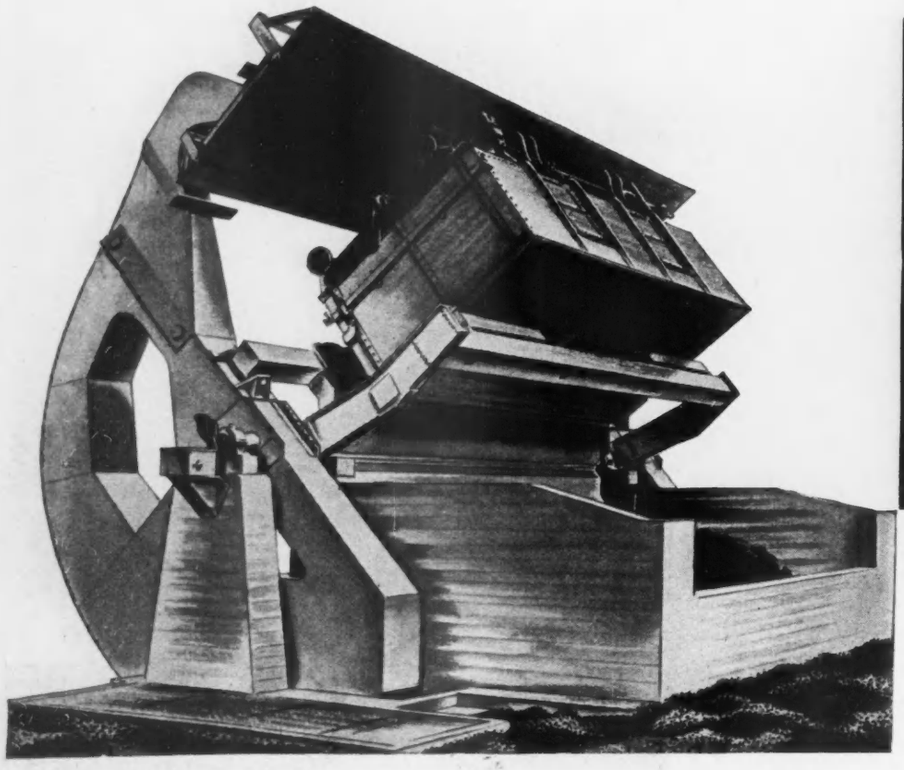
Giants of the West



Giant Bolster's favourite occupation was standing with one foot on St. Agnes' Beacon and the other six miles away on the Carn Brea hills, idly watching his wife quarrying granite. An imperfect husband, he is reported to have made a pass at St. Agnes herself—who promptly brought him to a gory end by a most unsaint-like trick. She agreed to marry him when he had filled a hole in a cliff at Chapel Porth with his blood—neglecting to tell him, however, that the hole was connected to the sea . . .

It would be interesting to have Bolster's opinion of modern giants of the West—like the S & H wagon tipplers—which patiently perform herculean labours with no trouble at all, domestic or otherwise.



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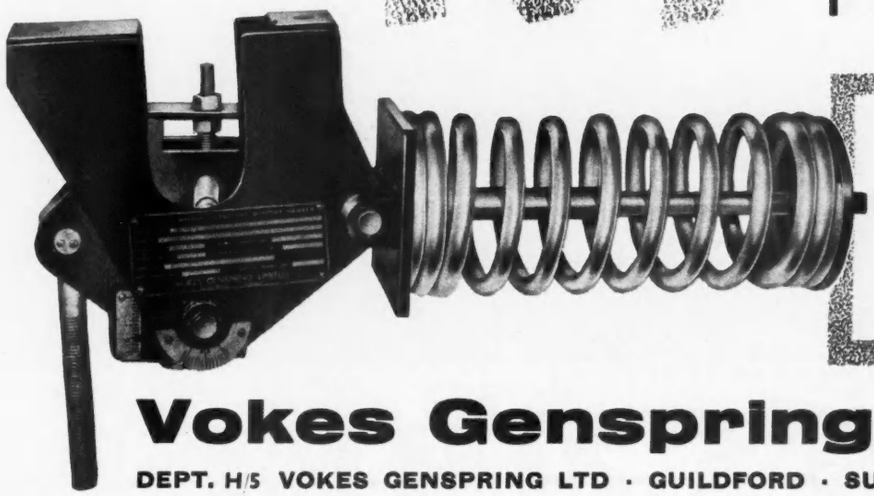
Vokes Genspring M range



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- Increased travel
- Less headroom required
- Suitable for all applications

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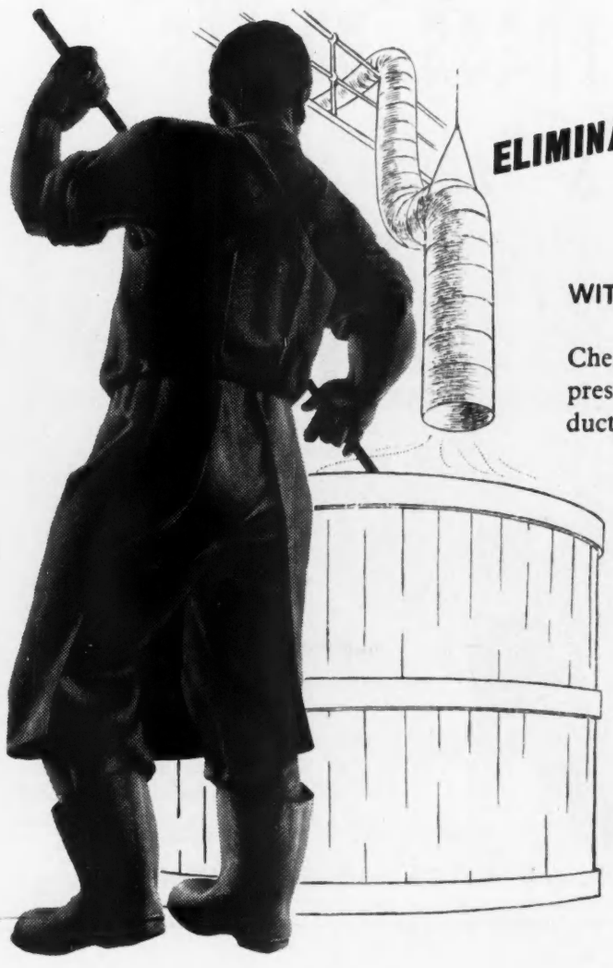

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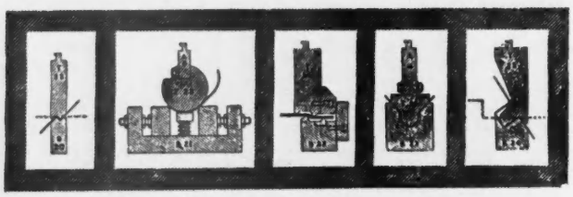

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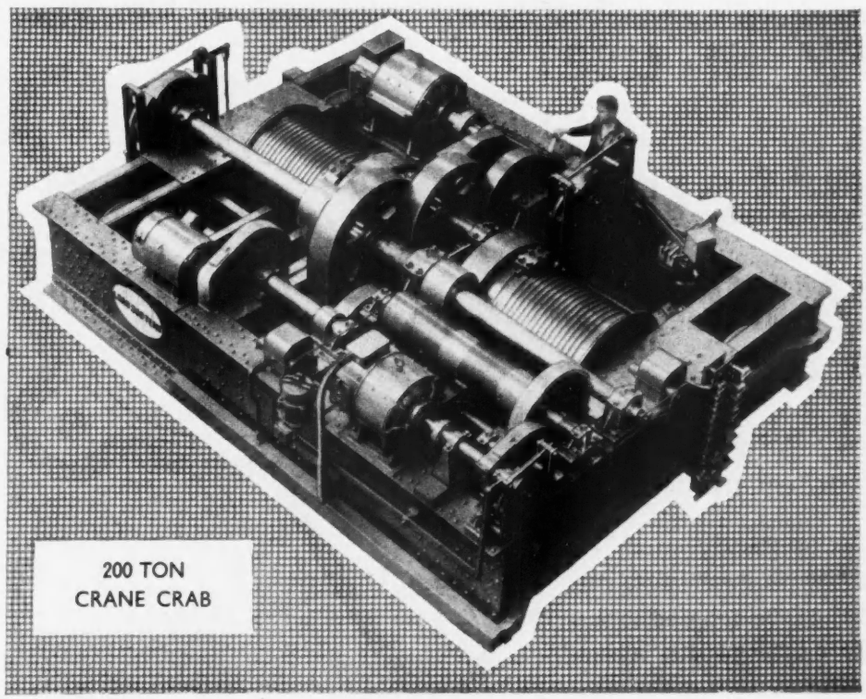

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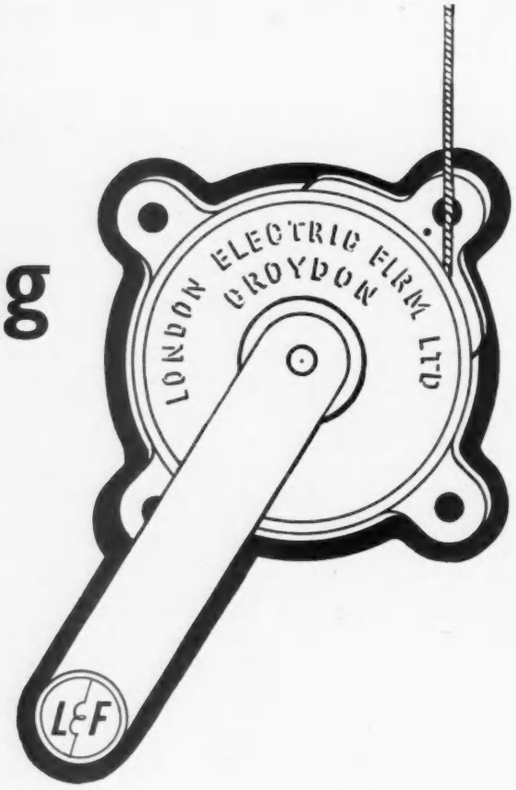

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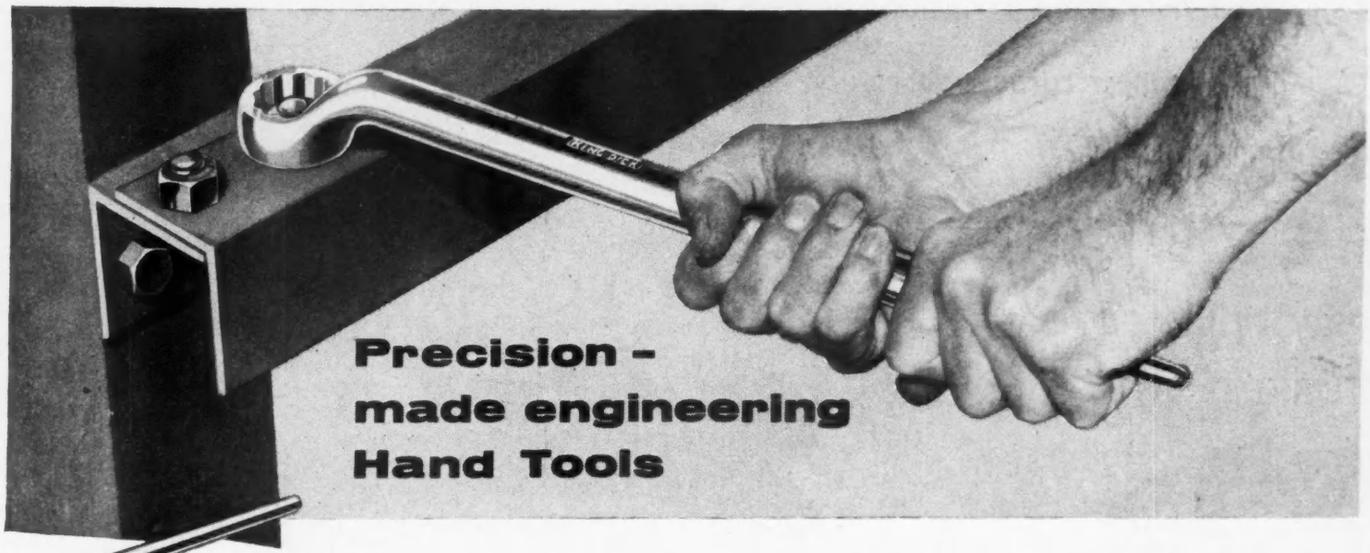

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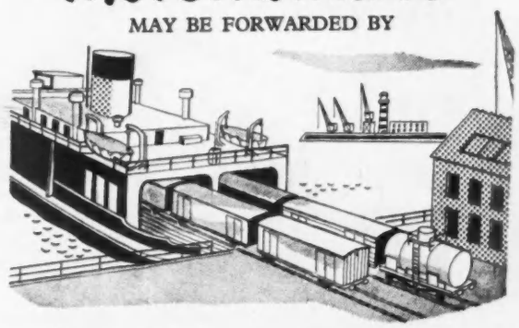

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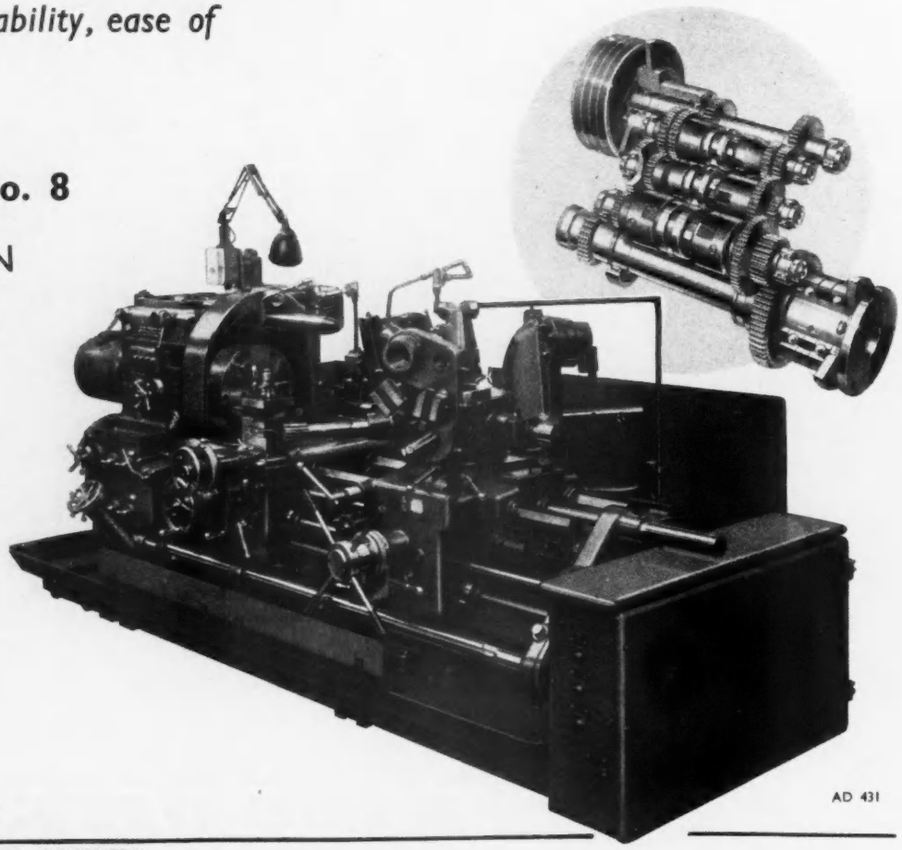

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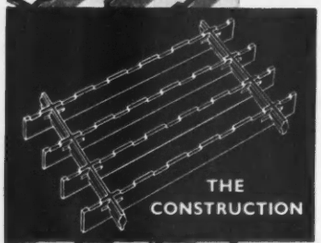

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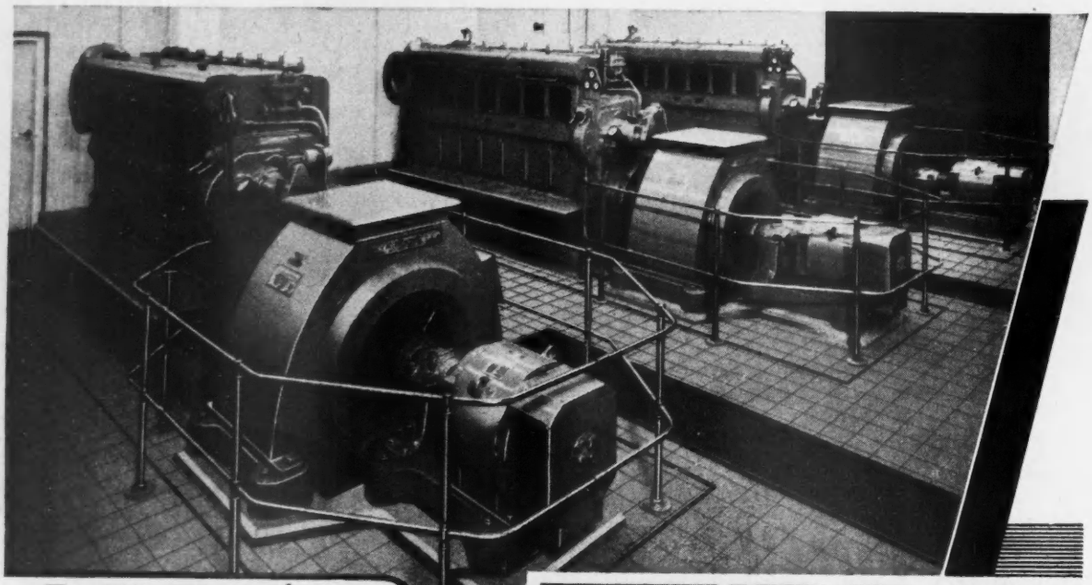

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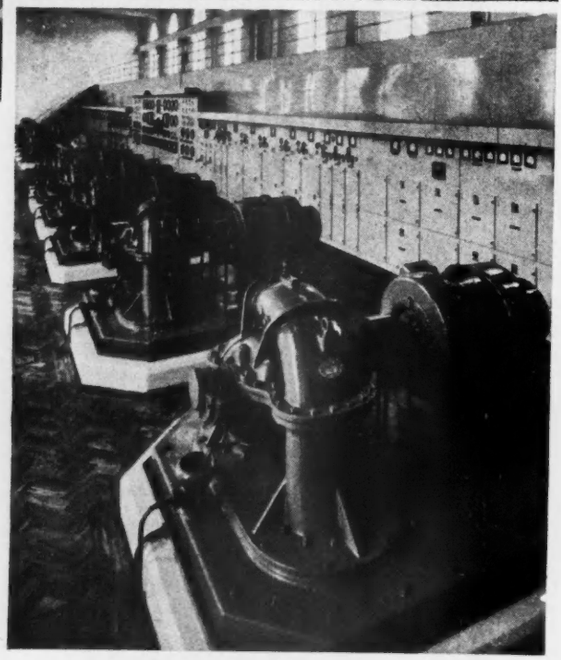

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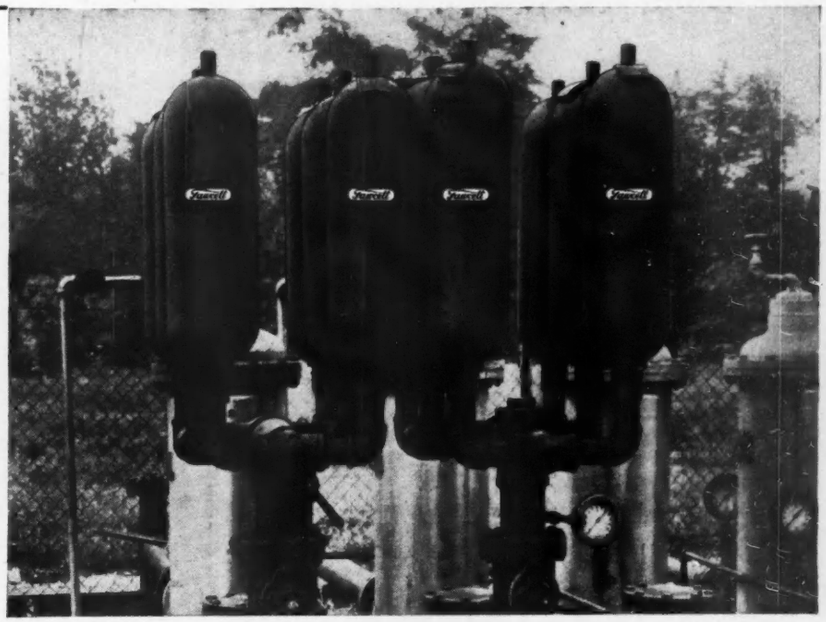

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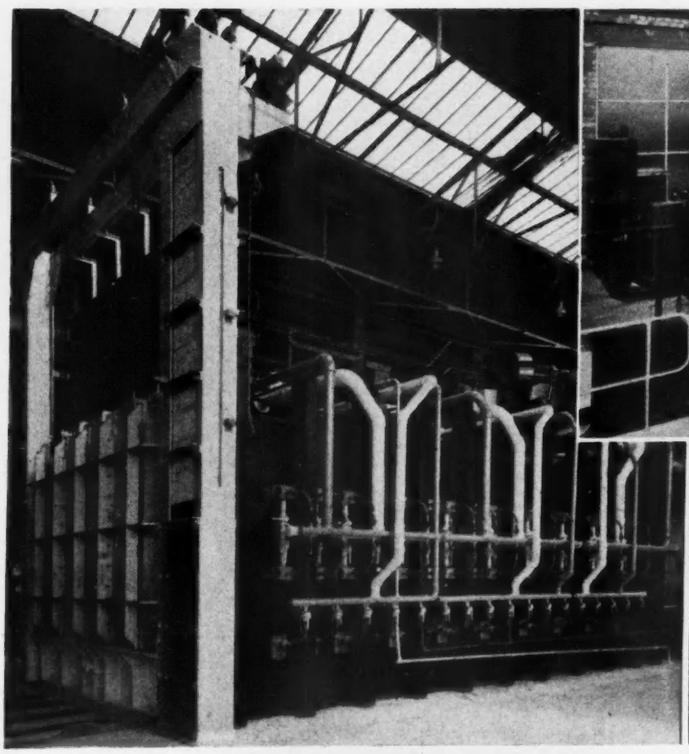

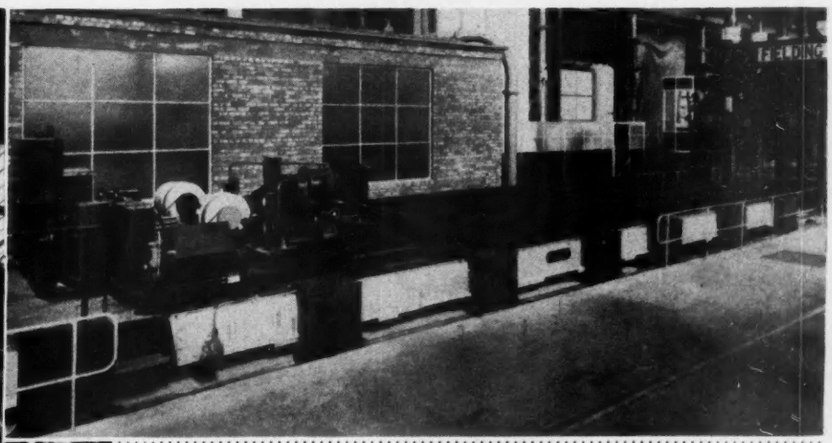

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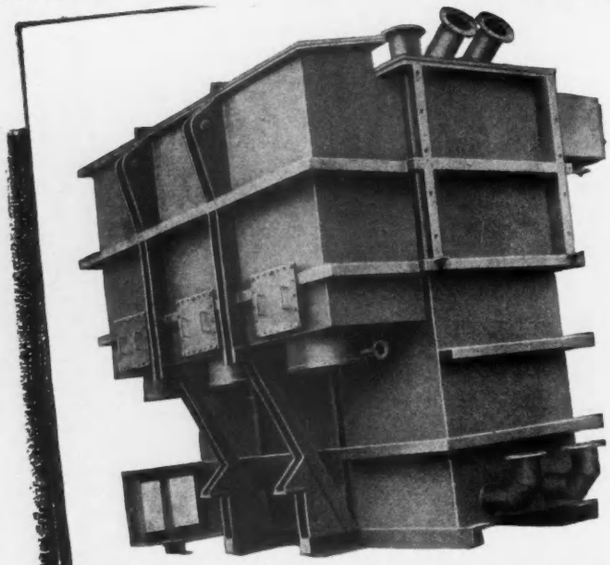

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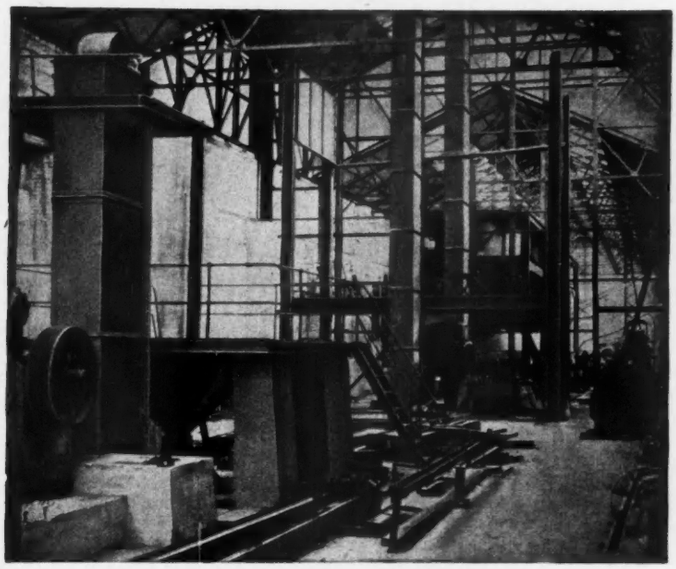

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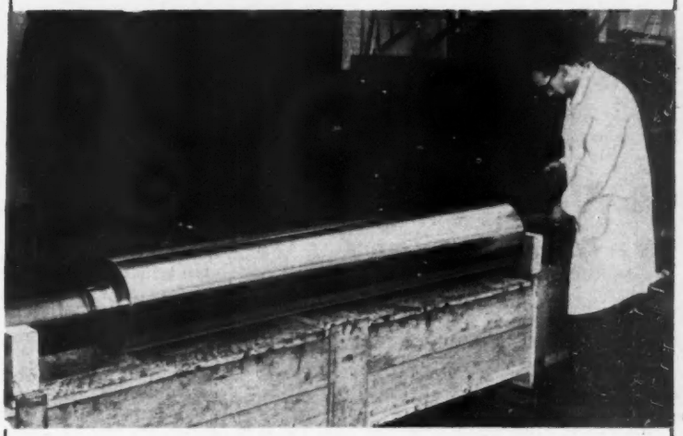

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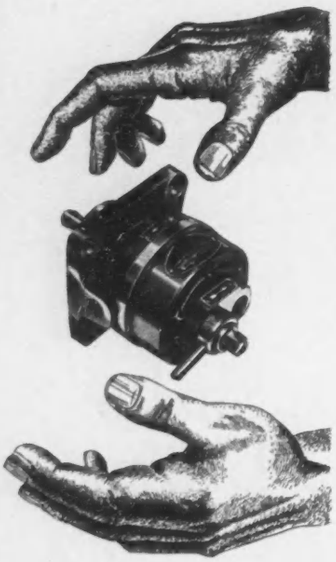

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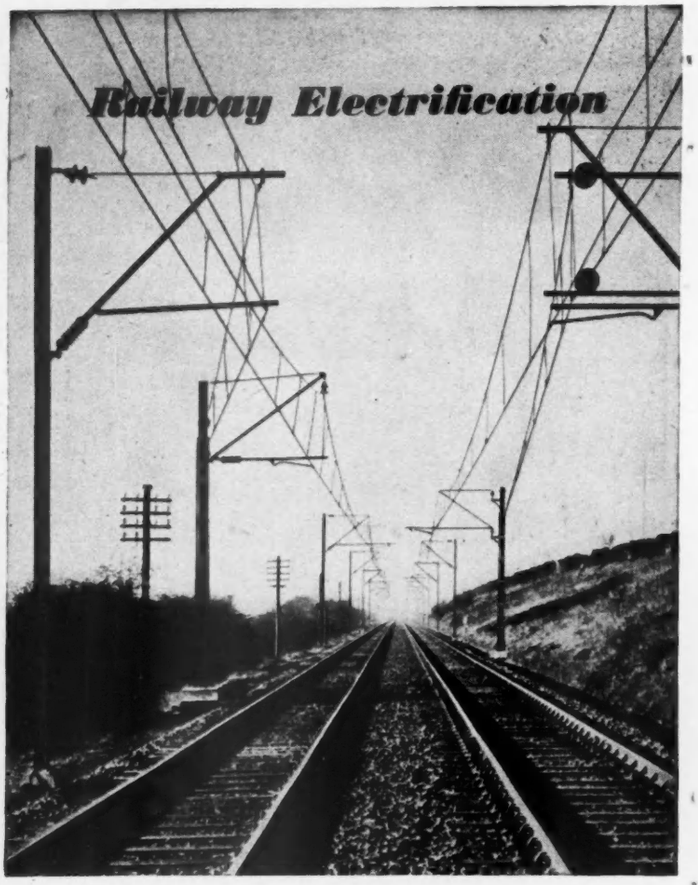

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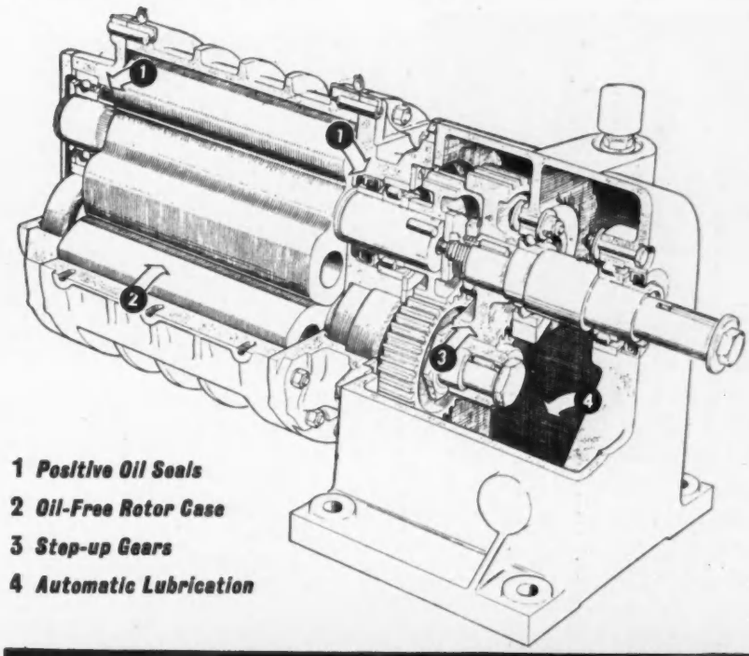

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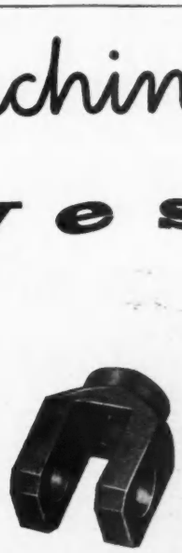

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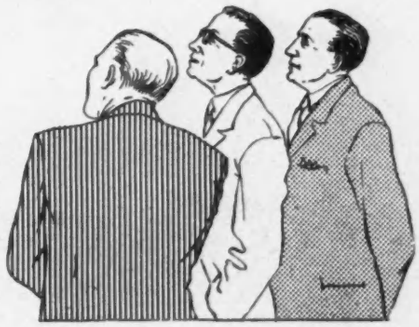

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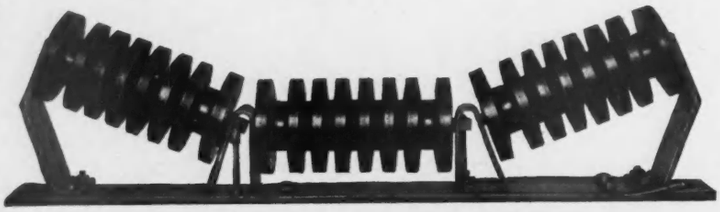

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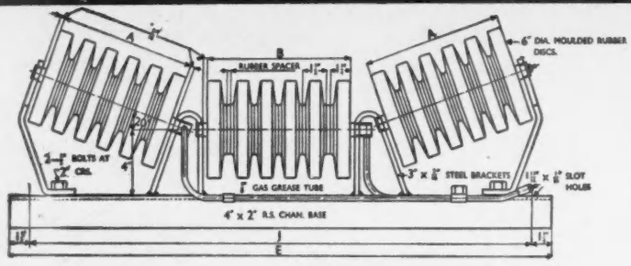
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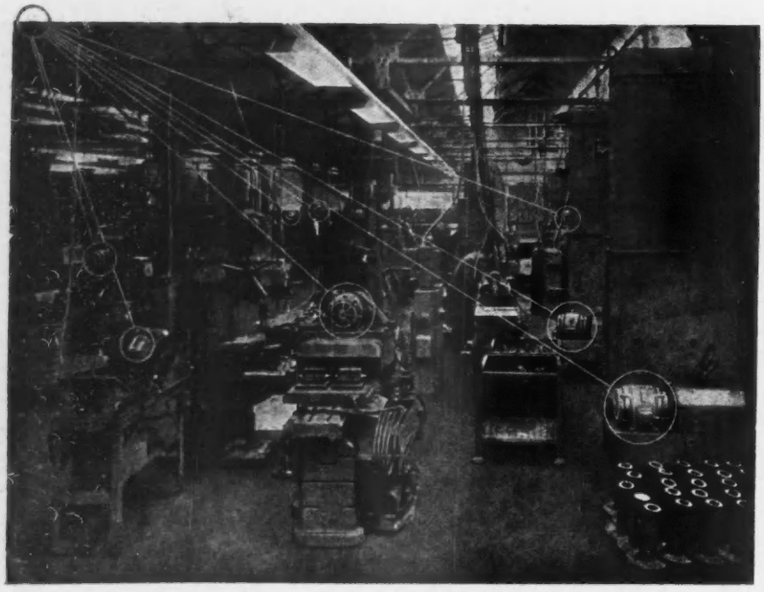

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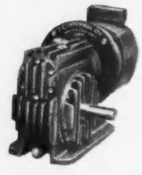

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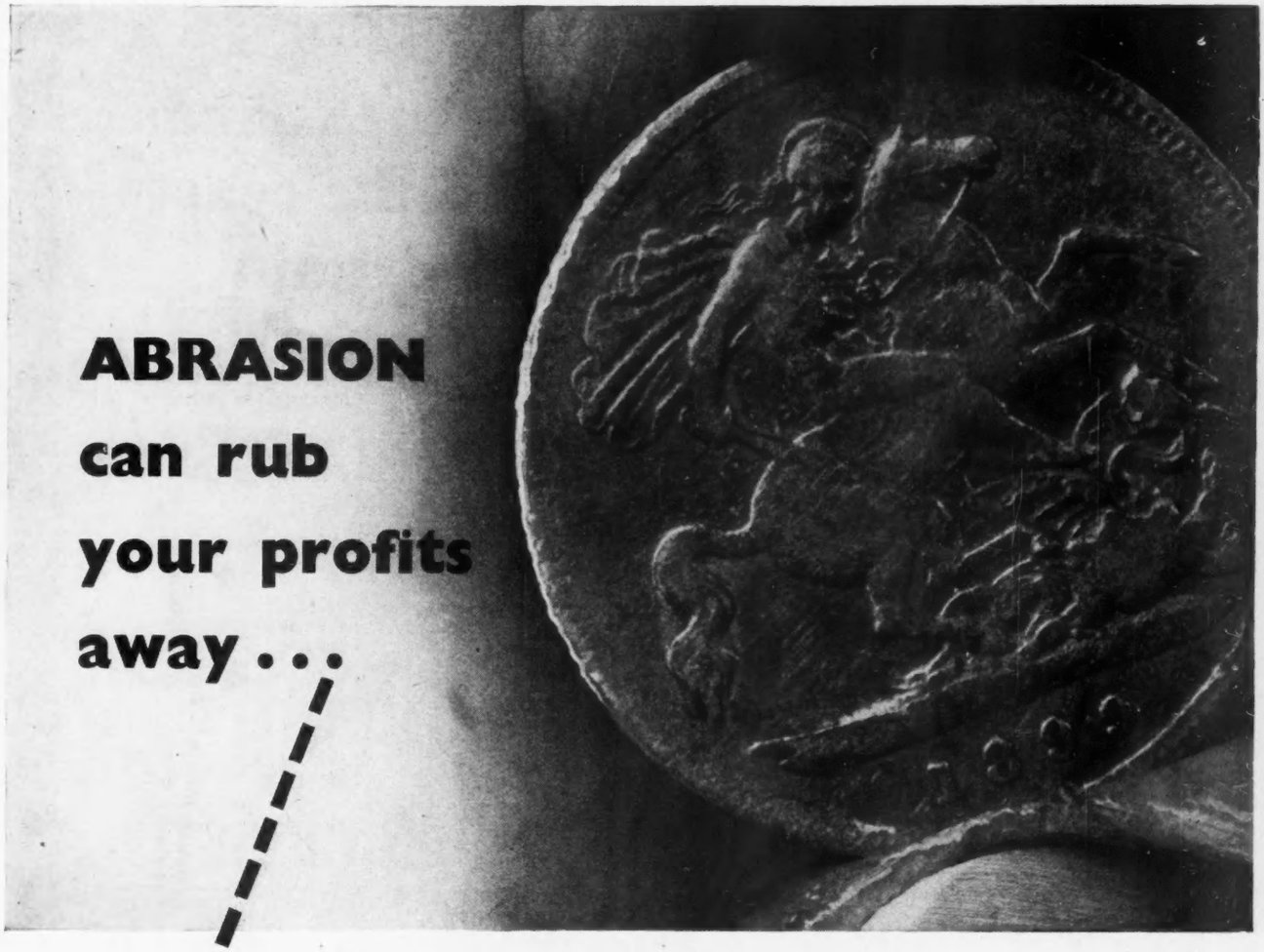

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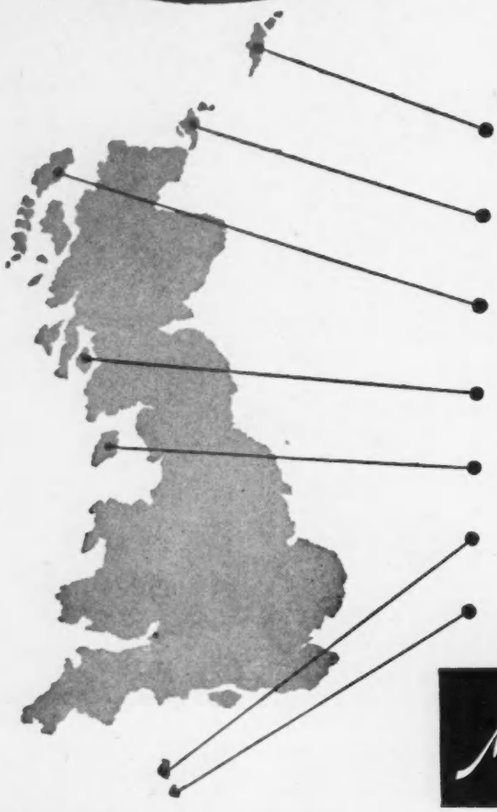

NORTH OF SCOTLAND HYDRO ELECTRICITY BOARD, LERWICK .. .. 2 MIRRLEES KVSS12 ENGINES, 1 MIRRLEES HF8 ENGINE

NORTH OF SCOTLAND HYDRO ELECTRICITY BOARD, KIRKWALL .. .. 2 MIRRLEES KVSS12 ENGINES

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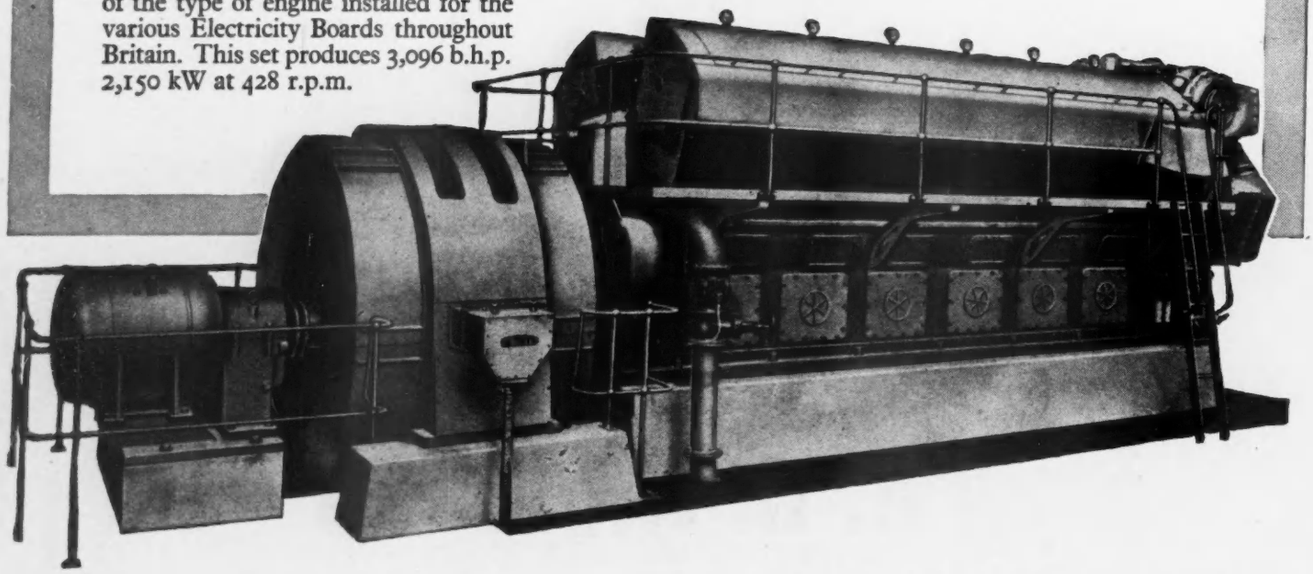
A Mirrlees KVSS12 Diesel Engine, coupled to a Brush Alternator, typical of the type of engine installed for the various Electricity Boards throughout Britain. This set produces 3,096 b.h.p. 2,150 kW at 428 r.p.m.



MIRRLEES, BICKERTON & DAY LTD., HAZEL GROVE, STOCKPORT, CHESHIRE

A member of the Hawker Siddeley Group

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Telegrams: 'Mirrlees Telex, Manchester'

IEa2

How HOPE'S made quite sure RUSTODIAN is the primer for galvanized steel windows

Rustodian has convinced Henry Hope & Sons Ltd., that there is nothing like a Calcium Plumbate Primer for galvanized metal window frames. Hope's are one of the largest makers of galvanized metal window frames in this country.

In their own words, in their own catalogue, they say:—

"PAINTING. As a priming coat we recommend the use of calcium plumbate primer 'RUSTODIAN'. This paint will adhere firmly to a newly galvanized window without any prior etching treatment. We deprecate the use of mordant solutions applied to windows on a building site. Calcium plumbate primer 'Rustodian' forms a good base for any good oil paint. It is advisable to apply the primer before glazing."

The exceptional adhesion and rust inhibiting properties of Rustodian are commending it to many other manufacturers, public authorities and architects for all iron and steel and galvanising. Rustodian is manufactured under British Patent No. 574626.

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Export enquiries to: ASSOCIATED LEAD MANUFACTURERS EXPORT CO. LTD., CLEMENTS HOUSE, 14 GRESHAM STREET, LONDON, E.C.2.

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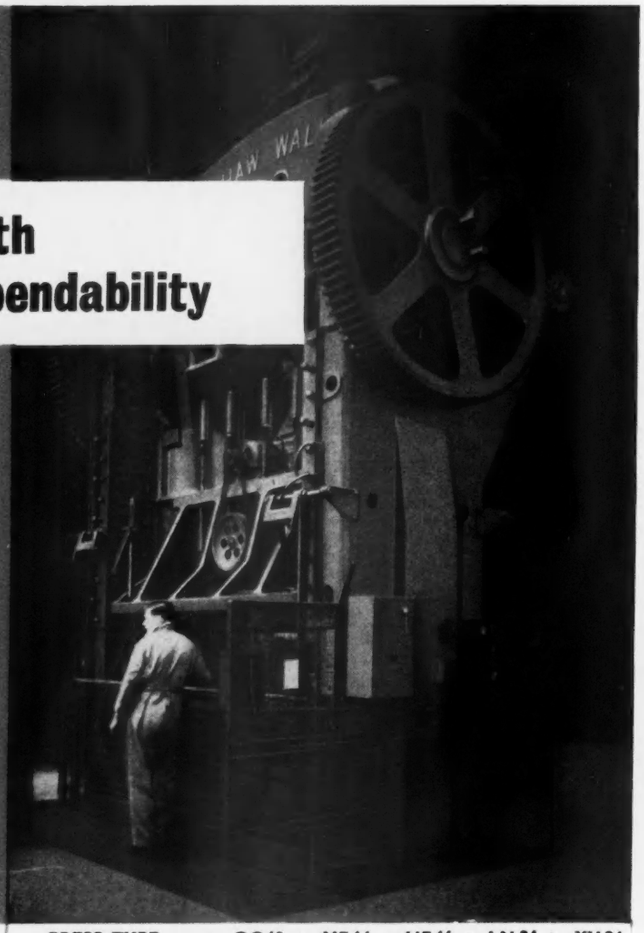
BOILERS and AIR RECEIVERS

See Display Advertisement Sept. 26



Presses with Inbuilt Dependability

It is with this range of large double crank tie rod presses that Cowlishaw, Walker & Co. Ltd have built their reputation for fine dependable machines. Note the clean lines, the massive frames and the exceptionally deep slide which ensure absolute die rigidity under the most adverse conditions of loading. All models in this range are fitted with the C.W. patent electro-pneumatic clutch-brake unit.

A selection from the range of C.W. double-crank presses

PRESS TYPE	OC.10	MF.14	UF.16	LN.24	YV.34
RATING: TONS	150	300	400	650	1500
CRANK DIA. ins.	7½	8½	10	12	15
BETWEEN SIDES ins.	75½	63	109½	109½	130½
STROKE ins.	10	14	16	24	34
SLIDE F to B x R to L ins.	30 x 68½	42 x 54	54 x 99½	63 x 99	70 x 120
BED F to B x R to L ins.	36 x 72	60 x 61	60 x 108	76 x 108	70 x 129
CUSHION: TONS	28	50	81	101	150

COWLISHAW, WALKER & CO. LIMITED

Biddulph, Stoke-on-Trent Telephone: Biddulph 3254 Telegrams: Cowlishaw, Stoke-on-Trent
London Office: 17 Victoria Street, S.W.1. Telephone: ABBey 6693

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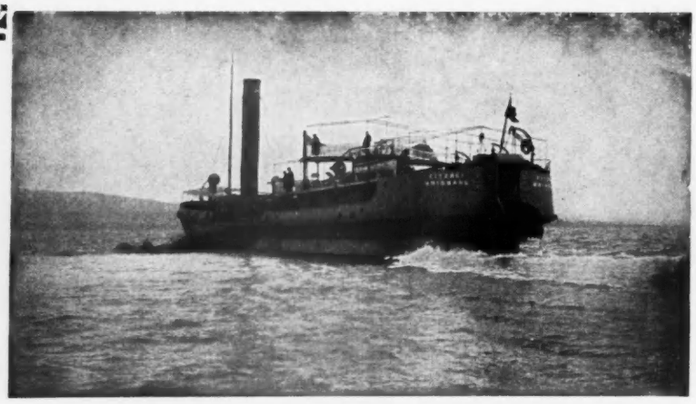
London Agents: Messrs. Nye & Menzies, Ltd., Capel House, 62, New Broad St., E.C.2
'Phone—London Wall 4846

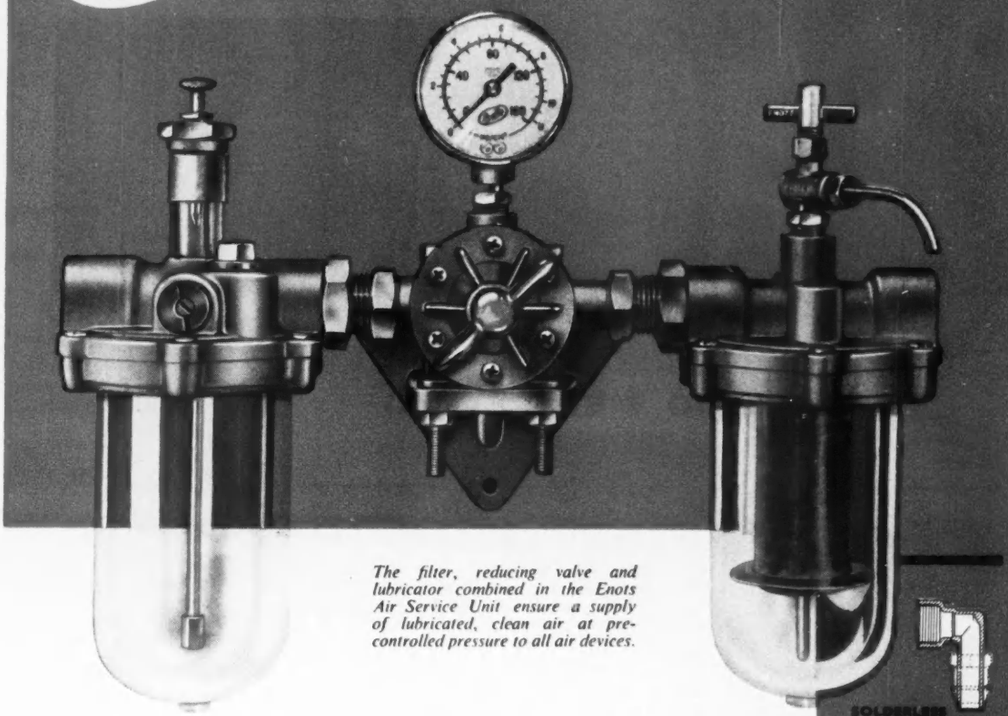


TWIN-SCREW TRAILING SUCTION HOPPER DREDGER "FITZROY"
built for the
QUEENSLAND GOVERNMENT, FOR ROCKHAMPTON
Dredging capacity : 1,000 cubic yards per hour
Vessel can suck from its 800-ton hopper delivering to a distance of 1,000 feet, to a height of 16 feet.

Enots

AIR SERVICE UNITS and PNEUMATIC EQUIPMENT

improve efficiency and reduce production costs



The filter, reducing valve and lubricator combined in the Enots Air Service Unit ensure a supply of lubricated, clean air at pre-controlled pressure to all air devices.

SOLDERLESS UNIONS

BLOW NOSE NOZZLE VALVES

A pressure reducing valve fitted to almost any pneumatic device will save its cost in a very short time by reducing air consumption. At how many points in your works are you using full line pressures of up to 100 lb. per sq. inch where 80, 60 or even lower pressures would be adequate? Savings are more or less in direct proportion to pressure reduction.

COPPER, BUNDY STEEL AND FLEXIBLE TUBES

EXHAUST SILENCERS

QUICK COUPLINGS

EJECTOR VALVES

LEAFLET AS357 describing our Air Service Units and individual components and other catalogues on Enots pneumatic devices are available on request.

BENTON & STONE LTD.,

ASTON BROOK STREET, BIRMINGHAM 6, ENGLAND. *Telephone: ASTon Cross 1905*

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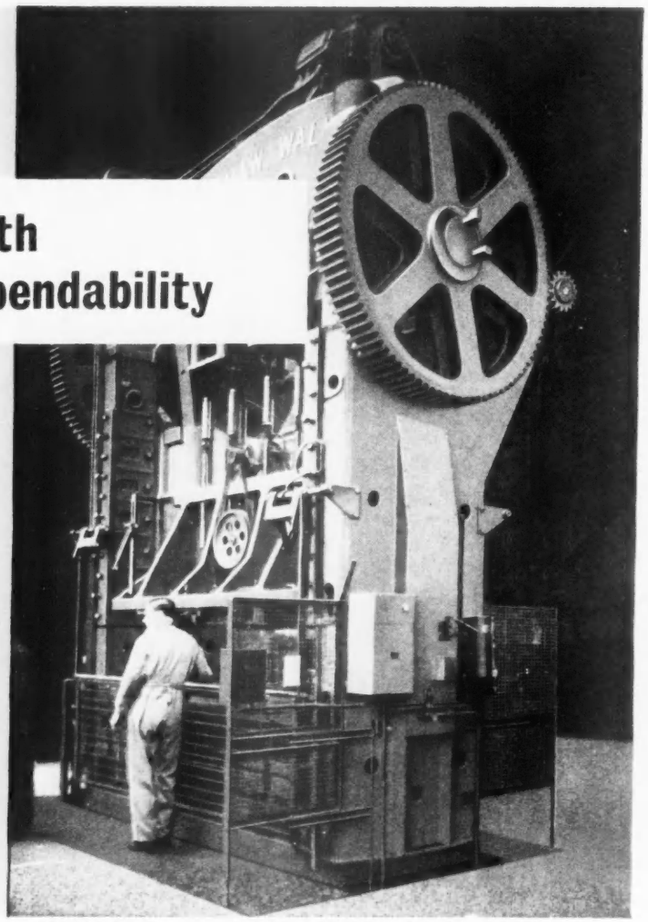

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PATENT CUTTER HOPPER DREDGERS. PATENT DIPPER DREDGERS. BUCKET DREDGERS. GOLD AND TIN RECOVERY DREDGERS. FLOATING CRANES

Hopper Barges, Screw Steamers, Side & Stern Paddle Wheel Steamers, Tugs, &c.
New Buckets, Links, Pins, Gearing, etc., supplied for existing Dredgers

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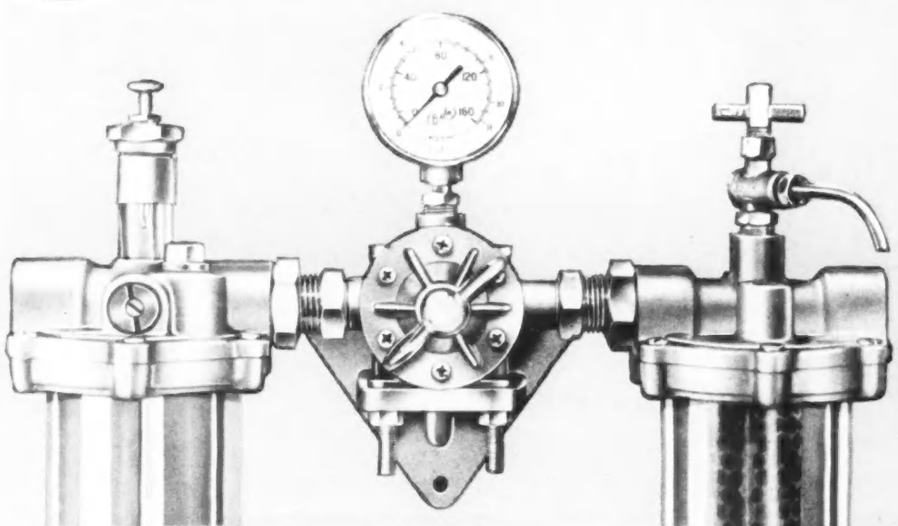
Erots

AIR SERVICE UNITS
and PNEUMATIC EQUIPMENT



The filter, reducing valve and lubricator combined in the Erots Air Service Unit ensure a supply of lubricated, clean air at pressures controlled for all air devices

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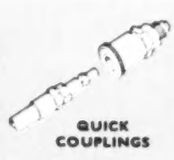
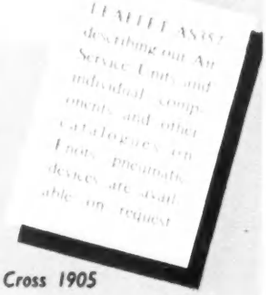


QUICK COUPLINGS

EJECTOR VALVES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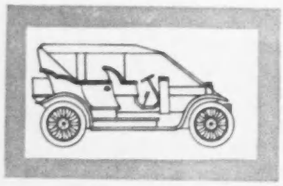

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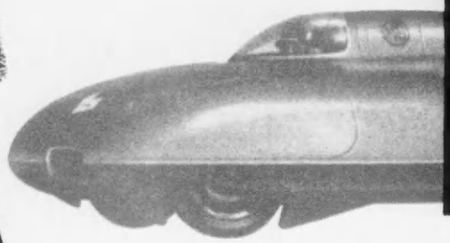

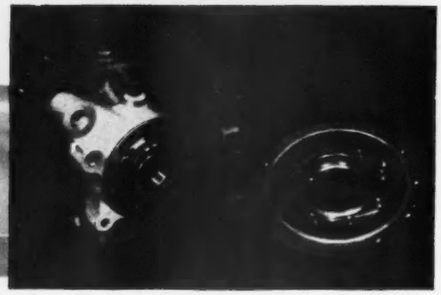

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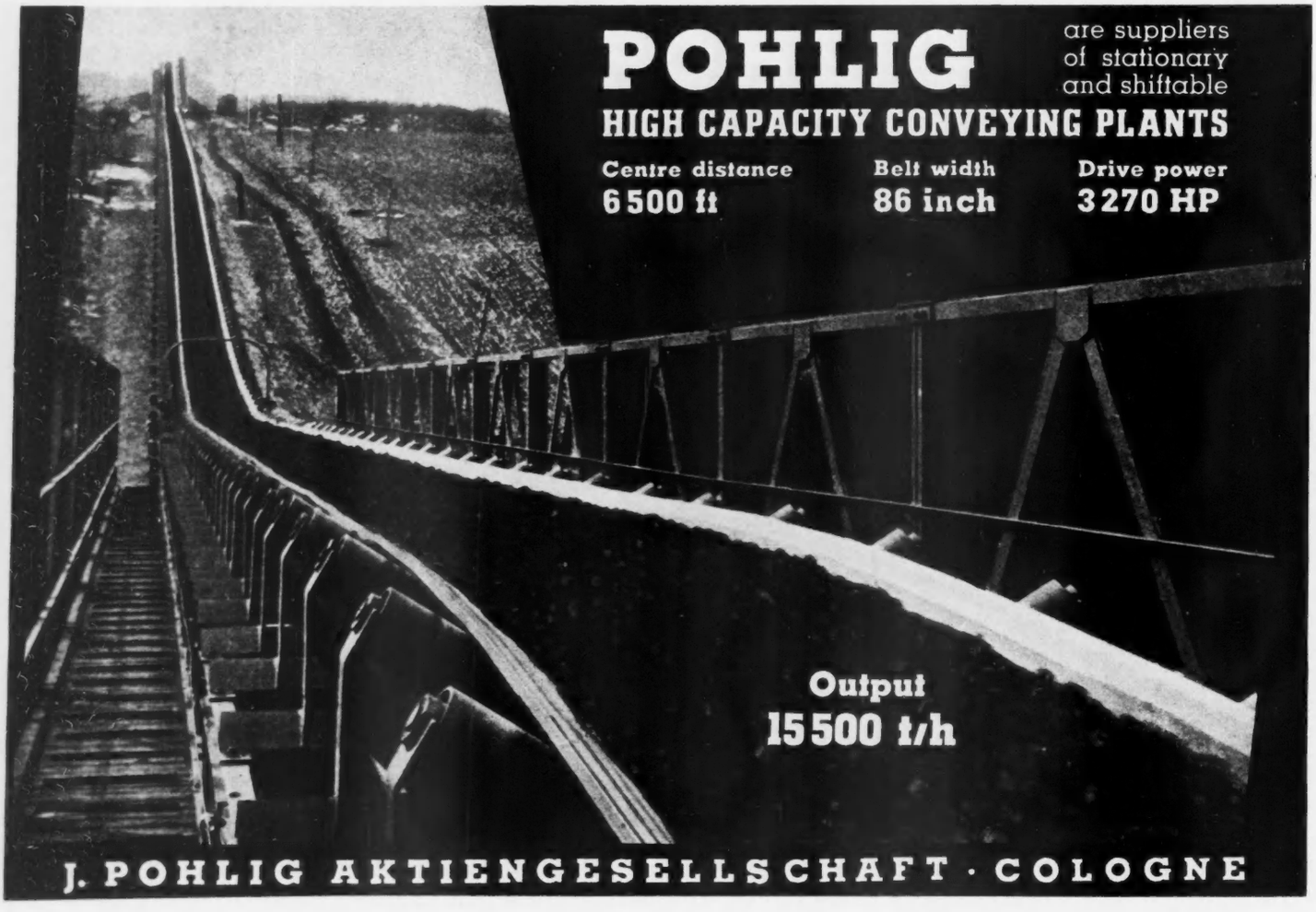
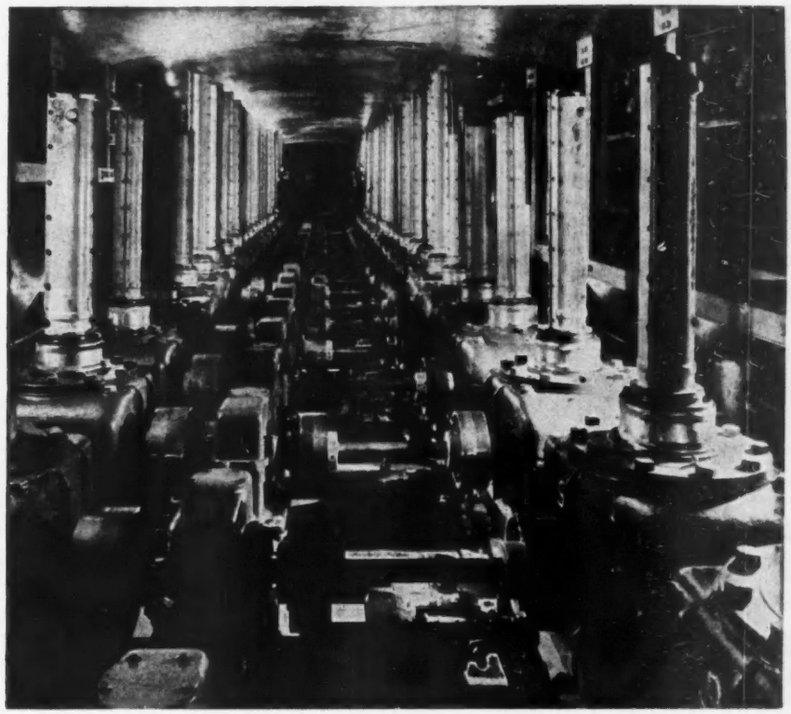


BIG JOBS

—such as supplying many special worm reduction gear units to the Royal Aeronautical Establishment for the supersonic wind tunnel at Bedford are not new to us here at Newbury, for besides non-standard units, our normal range of worm and spur units covers practically all industrial applications up to 120 h.p.



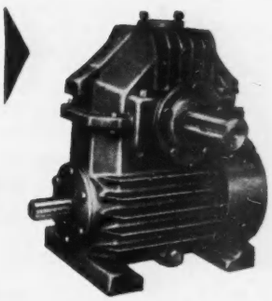
Type WGV 5¼ single reduction worm gearbox driven by WGV 4½ single reduction gearbox. As supplied to the Royal Aeronautical establishment, Bedford, for use in the 8ft. supersonic wind tunnel. The photograph shows part of the assembly of the working section of the tunnel.

AND SMALL JOBS

— such as the production of a small gear unit for an experimental pan and muller for grinding colours is another example of our standard range. Our compact, robust helical and spur geared motors are available as double or triple reduction units in six sizes, offering a complete range of horsepowers and output speeds to the user. You can't go wrong if you specify—

Laboratory colour Pan driven by a ½ h.p. drip proof geared motor unit, Type S.G.M.I. Ratio 22 : 1. Output speed 65 r.p.m. This photograph is reproduced by permission of William Boulton Ltd. Burslem, Staffs.

Type SUH horizontal shaft, fan cooled worm reduction gear. Standard sizes up to 12 in. centres; non-standard sizes up to 24 in. centres. Ratios 3:1 to 100:1.



GEARBOXES by OPPERMANS of NEWBURY

OPPERMAN GEARS LIMITED, NEWBURY, BERKSHIRE. *Telephone : Newbury 1701 (5 lines) Telegrams : Oppigears Newbury*

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M

Electrical Aids in Industry *Data Sheet* **No.1**

Electro-Heat

The ways in which electricity can be used to advantage in industry are many and varied. Some are well known but others are not known well enough. For this reason the Electrical Development Association has prepared a series of detailed data sheets on various applications which will be printed in this journal from time to time.

This Data Sheet is the first of a number devoted to electro-heat—that is, heat produced by electricity for the processing and treatment of materials. Other uses will be dealt with later on in the series.

There is an unalterable physical law that the efficiency of conversion of *electrical* energy to *heat* energy is 100 per cent. The same cannot be said of the efficiency of combustion of any solid or liquid fuel.

All the applications of electro-heat have these advantages in common :—

1 Electro-heat is clean both in regard to its application and the method of generation.

2 It can easily be controlled more precisely than any other form of heat, manually or automatically.

3 It can be brought to the job instead of having the job brought to it.

4 It permits better use of floor space and the elimination of unnecessary handling.

5 In many of the newer processes it is the only possible form of heat which can be used.

6 It often ensures a higher quality of products with fewer rejects.

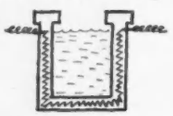
7 It gives the best working conditions.

8 It reduces or eliminates fire and explosion hazards.

Below will be found brief notes on some of the various methods of generating heat by electricity.

Resistance Heating

This is the best known form of electric heating. The elements provide a high resistance to the passage of electricity and thus heat is generated. It can be used in furnaces for melting or heat treatment of any material whether metal or not, or the resistance of the workpiece itself can cause the generation of heat.

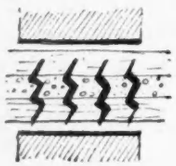


Induction Heating

Eddy currents are induced in the surface of a conducting workpiece, heating it up. The depth to which this heating will penetrate is determined by the time it is given.

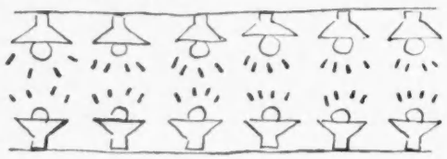
High-frequency Dielectric Heating

This form of electro-heat can be used only on non-conducting materials such as wood, plastic and rubber. The material is placed between two electrodes to which a high voltage is applied at a high frequency. This has the effect of generating heat inside the material rapidly and uniformly throughout its entire thickness.



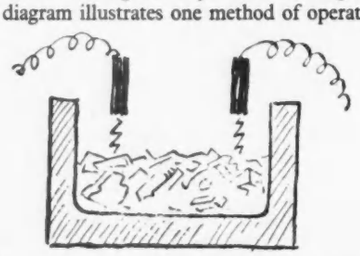
Infra-red Heating

This method employs pure radiant heat. The bulk of the radiation takes place in the infra-red portion of the radiation frequency spectrum. The heaters may take the form of reflector lamps or sheathed wire elements. The method is extremely flexible and has many uses, including paint drying and pre-heating plastics.



Arc Melting

This form of heating is chiefly used for melting steel. The diagram illustrates one method of operation.



Very large charges can be melted; melting units of 200 tons capacity are now in operation.

The Application of Electro-Heat

All these methods of electric heating can be applied in almost an infinite variety of ways. Some of these ways will be dealt with in subsequent sheets.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2.

Excellent reference books on electricity and productivity (8/6 each or 9/- post free) are available—"Induction and Dielectric Heating" is an example; "Resistance Heating" is another.

E.D.A. also have available on free loan a series of films on the industrial use of electricity. Ask for a catalogue.

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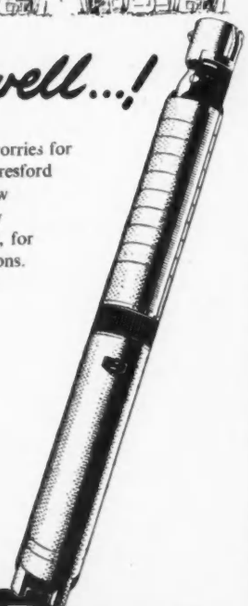
Three wells and no more water worries for the owners—if each well has its Beresford Submersible pump installed below water level, quietly and efficiently providing all the water required, for little more than 1d. per 1,000 gallons. They're ideal for automatic operation, are made of non-corrosive bronze and stainless steel, occupy no surface space and cause no nuisance. They are, in fact, the ideal modern pumps for domestic, agricultural and industrial water supply, particularly for use in deep wells and bore-holes. May we send you a copy of descriptive leaflet P.G.300 ?



BERESFORD submersible **pumps**

The James Beresford & Son, Limited,
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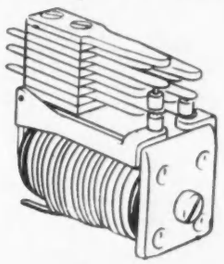
Thorn

NEW PYGMY CONTROL RELAY

An open relay ideally suited to light duty control circuits



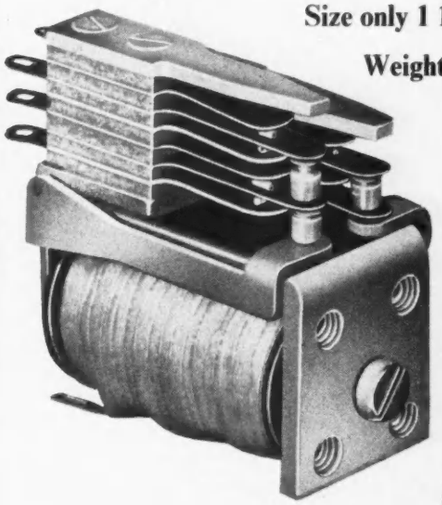
Low current consumption— operates on ⅓ W.

Up to four changeover contacts.

Wide range of coil voltages.

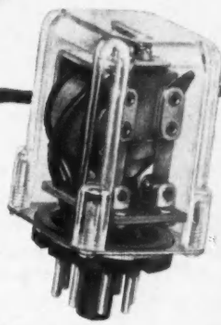
Size only 1 19/32″ x ¾″ x 1½″.

Weight only two ounces.



Switching current:
Up to 3 amps. 110 Volts A.C.
1 amp. 24 Volts D.C.
Operate time:
8 milliseconds approx.
Release time:
3 milliseconds approx.
Overall dimensions:
1 19/32″ x ¾″ x 1½″.
Coil voltages:
Up to 72 Volts D.C.
Weight: 2 oz. approx.

THORN PYGMY POWER RELAY



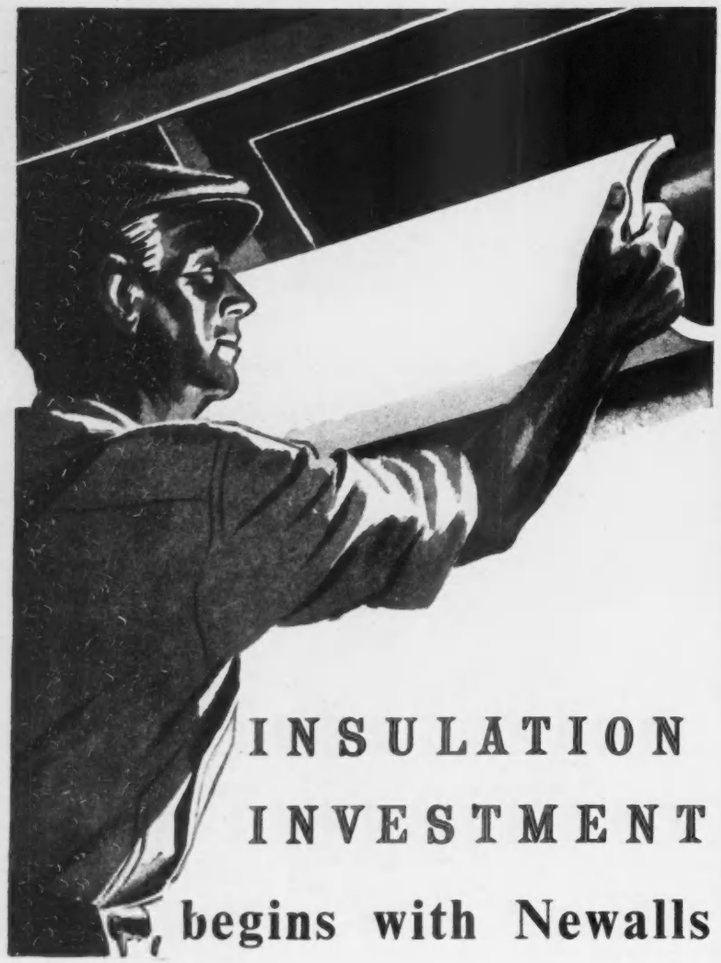
Mechanical life over 10,000,000 operations.
New interchangeable relay designed for use in remotely controlled automation units.
Has double pole changeover contacts.
Dust proof—transparent plastic cover.
Plugs into any standard International octal valve base.
Weight only 4½ oz. . . . projection only 2″ above base.
Robust construction.

Switching current:
5 amps maximum at 250 volts A.C.
Maximum surge current:
10 amps.
Operate time:
8 milliseconds approx.
Release time:
6 milliseconds approx.
Overall dimensions:
1⅞″ square by 2 9/32″.
Coil voltage: 240 volts standard; also available for 6, 12, 24, 48, 60, 110 volts either AC or DC.

THORN PYGMY RELAYS...

the most economically priced relays of their type

AIRCRAFT COMPONENTS & CONNECTOR DIVISION
THORN ELECTRICAL INDUSTRIES LIMITED
GREAT CAMBRIDGE ROAD ENFIELD MIDDLESEX TEL: ENFIELD 5353



INSULATION INVESTMENT begins with Newalls

ALL OVER THE COUNTRY our contracting staffs, working from 8 major depots in the main centres, are at work. A power station on the North East Coast . . . a cold store in Glasgow . . . a chemical works in South Wales . . . an industrial boiler installation in the Midlands . . . these are typical contracts. The men on the job are employing first rate materials—Newalls insulation specialities, which are manufactured to cover all temperature ranges from minus 300°F up to over 2,000°F. But they bring more than such materials to the job. Newalls make a point of studying the factors affecting the application of their materials, so that performance of the insulation has already been pre-determined before the contract has been started. This, coupled with a background of thousands of completed contracts using all types of insulation, adds up to an experience which supplements and transcends designs and specifications.

Good thermal insulation *is* an investment—that's why so many organisations, large and small, turn to Newalls for technical advice and consultation.

Where there's a problem of INSULATION there's a job for

Newalls

NEWALLS INSULATION CO. LTD. *Head Office:* WASHINGTON, CO. DURHAM
A member of the TURNER & NEWALL ORGANISATION
Offices and Depots at LONDON, GLASGOW, MANCHESTER, NEWCASTLE UPON TYNE BIRMINGHAM, BELFAST, BRISTOL & CARDIFF. *Agents and Vendors in most markets abroad.*

SHEET METAL WORK

For all requirements consult

EDGAR C. BURRELL & SONS LTD.
THE CONGE, GT. YARMOUTH, NORFOLK. TEL. 3894

Schieldrop

OIL FIRED BOILERS

We Guarantee

13½ to 14 per cent CO_2 with Shell Smoke number 4 or less.

Schieldrop & CO. LTD
STOTFOLD, BEDS. Tel. 414 (3 lines) OFFICES AT : BIRMINGHAM · LONDON · MANCHESTER SWANSEA · GLASGOW.

BM

THERMOMETERS

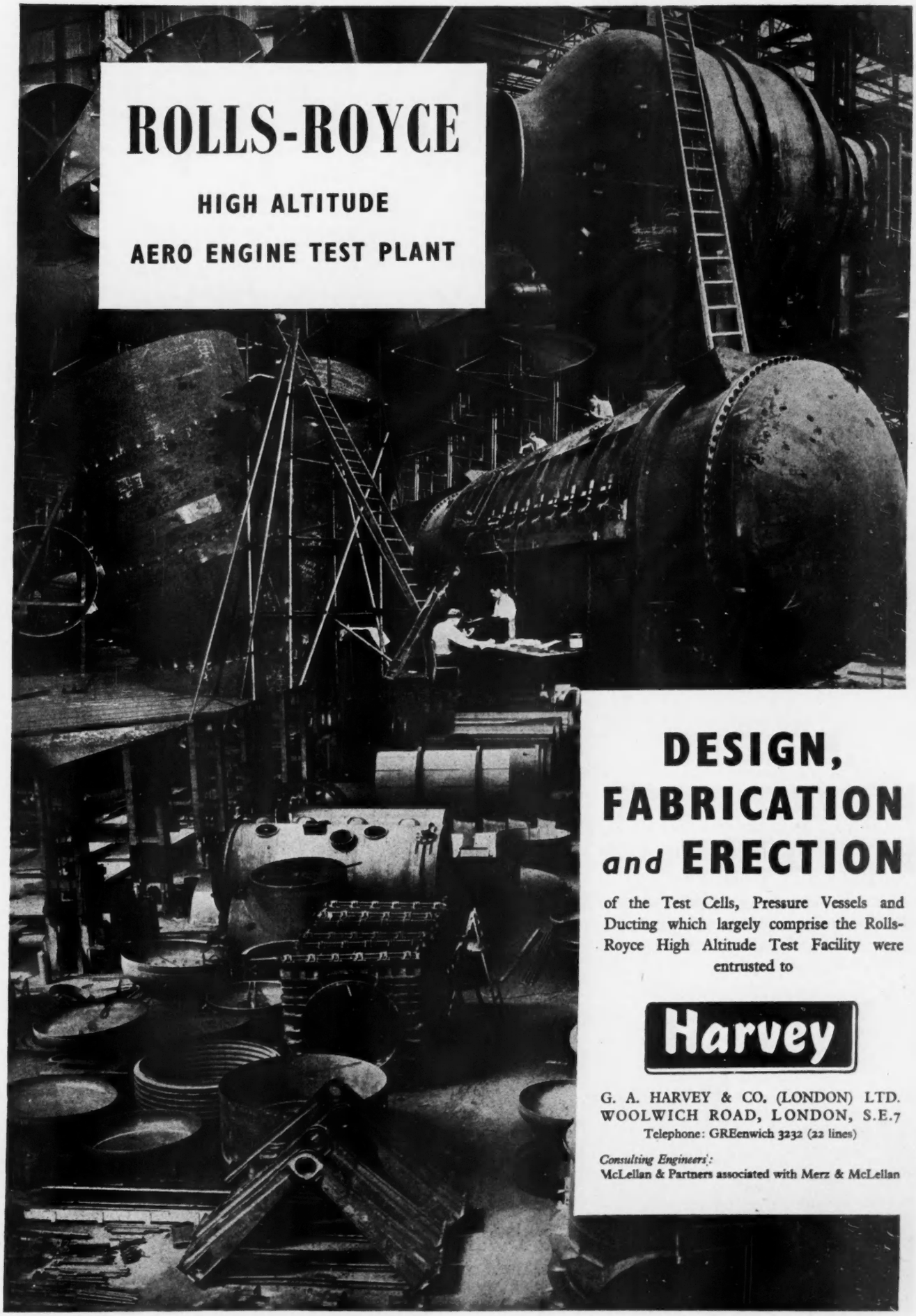
MERCURY-IN-STEEL AND VAPOUR THERMOMETERS

Mercury-in-Steel indicating thermometers are made with 4", 6", 8" or 10" dials with ranges between 20°F and 1,200°F Available with rigid stem for local mounting, or in surface or flush mounting cases for distance indication. Bulbs, pockets and capilliary coverings are made to suit all purposes. Vapour thermometers with 3", 4" or 6" dials are made with ranges up to 500°F.

Budenberg

BUDENBERG GAUGE CO. LTD. · BROADHEATH, Nr. MANCHESTER.
London: Regency House, 1-4 Warwick St., W.1. Tel.: GERrard 4822-3
Grams: Pyrometer, Piccy, London. Glasgow: 62 Robertson St., C.2.

dmBU.39



DESIGN, FABRICATION *and* ERECTION

of the Test Cells, Pressure Vessels and Ducting which largely comprise the Rolls-Royce High Altitude Test Facility were entrusted to

Harvey

G. A. HARVEY & CO. (LONDON) LTD.
WOOLWICH ROAD, LONDON, S.E.7
Telephone: GREenwich 3232 (22 lines)

Consulting Engineers:
McLellan & Partners associated with Merz & McLellan

POWER STEERED MOBILITY

The most versatile Handling Crane

HYSTER KARRY KRANE

—more than lives up to its name! The Hyster Crane carries loads up to 10,000 lb. and with adjustable boom (five positions) handles heavy materials with maximum speed and mobility. If required, a Hydraulic Topping Boom is available. Equipped with automotive controls for easy operation in outdoor and indoor conditions. Good visibility too! Fitted with pneumatic tyres.

Write to your dealer for details. It's high time you settled for Hyster.

Increases Efficiency Saves Labour

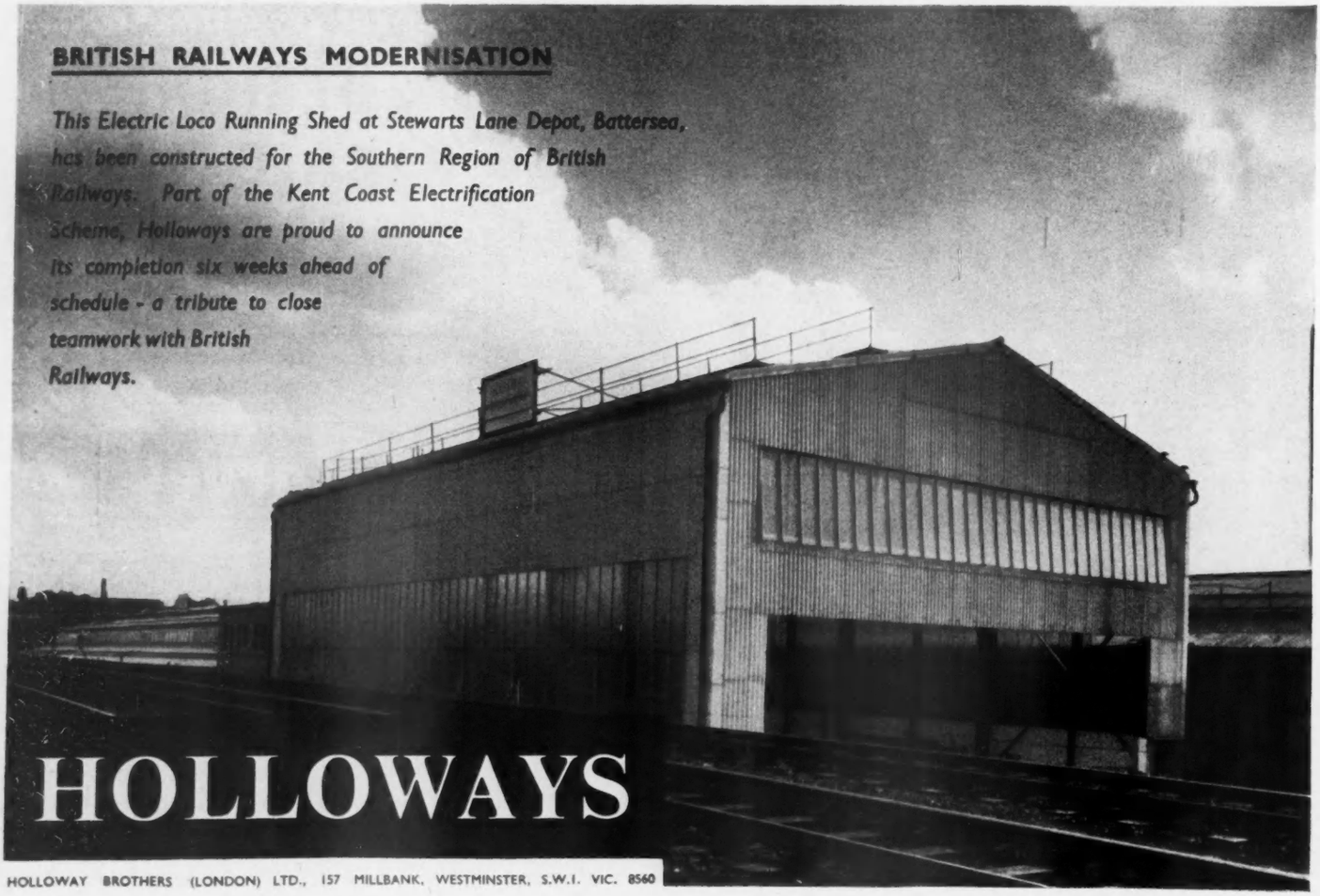
MODEL KE KARRY KRANE CAPACITIES:
Single line 6,000 lb.
Two-part line 10,000 lb.

YOUR U.K. HYSTER DEALERS FOR SALES AND SERVICE

- Fred Myers Ltd., 24 Bruton Street, Berkeley Square, London, W.1.
- Bowmaker (Plant) Ltd., Willenhall, Staffs.
- Caledonian Tractor & Equipment Co. Ltd., Rigby Street. Glasgow, E.1.
- H. Leverton & Co. Ltd., Spalding and Leeds.

BRITISH RAILWAYS MODERNISATION

This Electric Loco Running Shed at Stewarts Lane Depot, Battersea, has been constructed for the Southern Region of British Railways. Part of the Kent Coast Electrification Scheme, Holloways are proud to announce its completion six weeks ahead of schedule - a tribute to close teamwork with British Railways.



HOLLOWAYS

HOLLOWAY BROTHERS (LONDON) LTD., 157 MILLBANK, WESTMINSTER, S.W.1. VIC. 8560

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-.
Inch Rate. 48/- per single column inch and *pro rata*. 12 lines to 1 inch.
There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

Lineage Rate. 3/6 per line of approximately 6 words. Minimum 14/-.
Inch Rate. 42/- per single column inch and *pro rata*. 12 lines to 1 inch.
There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £22. ½-page £41 10s. Full page £78.

Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-on and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.
Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.
Use of Box Number. 2/- which includes forwarding of replies.
Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

***Advertisements for publication should be addressed to:*—Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

UNIVERSITY OF CAPE TOWN, SOUTH AFRICA

LECTURESHIP IN ELECTRICAL ENGINEERING

Applications are invited for a LECTURESHIP in the Department of Electrical Engineering. The Lecturer's main qualifications may be either in the power field with experience in electrical machines or in the electronics or communications field.

The salary scale is £850 by £50 to £1200 per annum. There is also a temporary cost-of-living allowance (at present £234 per annum for a married man).

Applications should state age, experience, qualifications and research work completed or in progress, and should give the names of two referees whom the University may consult.

Two copies of the application and testimonials should reach the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1 (from whom memoranda giving the general conditions of appointment and details about the department should be obtained), not later than 15th November, 1958. An additional copy must be sent direct by airmail to the Registrar, University of Cape Town, Private Bag, Rondebosch, Cape Town, South Africa, by the same date.

The University reserves the right to appoint a person other than one of the applicants or to make no appointment. E8803

UNIVERSITY OF CANTERBURY, CHRISTCHURCH, NEW ZEALAND

LECTURER IN MECHANICAL ENGINEERING

Applications are invited for the above position. Applicants must possess a Degree in Mechanical Engineering of a recognised Commonwealth University, preferably at Honours standard, or an equivalent qualification; experience of modern drawing-office practice would be desirable.

The salary attached to the position will be at the rate of £1025 per annum, rising by annual increments of £50 to £1275 per annum. An allowance is made towards travelling expenses.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1.

The closing date for the receipt of applications, in New Zealand and London, is 30th November, 1958. E8811

UNIVERSITY OF WESTERN AUSTRALIA

SENIOR LECTURESHIP OR LECTURESHIP IN MECHANICAL ENGINEERING

Applications are invited for the above-mentioned position. The status of the appointee will depend on qualifications, age and experience. Preference will be given to those applicants with some experience and interest in:

(i) Industrial Management, Workshop Practice, and related topics.

(ii) Metallurgy, and Engineering Materials (properties and handling).

Conditions of appointment and general information are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1.

Applications close, in Australia and London, on 29th November, 1958. E8809

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF MINING AND FUELS

CHIEF TECHNICIAN

CHIEF TECHNICIAN required to take charge of the workshop and laboratories of the above Department. Applicants should be widely experienced in Electrical Engineering, including Electronics, and possess a Higher National Certificate or equivalent qualification. Salary within the scale £715 by £20 to £795. Pension scheme. Conditions of Appointment and Form of Application, to be returned as soon as possible, from the Registrar. E8815

UNIVERSITY OF WESTERN AUSTRALIA

LECTURESHIP IN CIVIL ENGINEERING

Applications are invited for the above-mentioned position. The Lecturer will be required to give instruction and to conduct practical classes in drawing and graphical methods to first and second-year students. He may also be required to assist with other classes, and in the testing laboratory.

Salary: £A1550–£A2050 p.a.

Conditions of appointment and general information are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1.

Applications close in Australia and London on 29th November, 1958. E8812

UNIVERSITY OF LONDON KING'S COLLEGE

FACULTY OF ENGINEERING

METALLURGIST

ENGINEER OR PHYSICIST

Applications are invited for appointments as:
(a) METALLURGIST:
(b) ENGINEER OR PHYSICIST.

A grant from the Nuffield Foundation enables King's College to offer two research posts to Graduates suitably qualified in Metallurgy for (a) and in Physics or Engineering for (b). The research work will be in the field of Biomechanics, which is the application of the principles of engineering science to the practice of surgery and medicine. A well-equipped laboratory for Biomechanics is available.

The emoluments for post (a) will be in the range of £900–£50–£1200, with F.S.S.U. and family allowance, and for post (b) £500–£650. It is intended that the successful candidates should be eligible to read for a higher Degree of the University of London.

Application forms may be obtained from the Registrar, King's College, London, Strand, W.C.2. Completed forms must reach him by October 31st. E8786

BOURNEMOUTH EDUCATION COMMITTEE

BOURNEMOUTH MUNICIPAL COLLEGE OF TECHNOLOGY AND COMMERCE

ASSISTANT GRADE "B"

Required, for 1st January, 1959:
ASSISTANT GRADE "B" in the Department of Mechanical Engineering, to teach mechanical engineering subjects to the standard of the A2 year of the Higher National Certificate.

It is desirable that applicants should have a Degree or equivalent qualification and some teaching experience.

Salary according to the Burnham Technical Scale, 1956, viz.:

Men £650 by £25 to £1025, women £580 by £20 to £820, with additions for training, qualifications and experience.

Further particulars and application forms obtainable from W. R. Smedley, Chief Education Officer, Town Hall, Bournemouth. E8804

NORTH RIDING EDUCATION COMMITTEE

CLEVELAND TECHNICAL COLLEGE, REDCAR

ASSISTANT GRADE A

Applications are invited for the post of ASSISTANT GRADE A for Machine Shop Practice.

Forms and particulars available from me on receipt of stamped, addressed envelope. Completed forms to be returned by 21st October, 1958.

F. BARRACLOUGH.
County Hall,
Northallerton. E8813

UNIVERSITY OF ADELAIDE, AUSTRALIA

LECTURER IN MECHANICAL ENGINEERING

Applications are invited for the above appointment; applicants should preferably have drawing and design experience.

Salary scale: £A1420–£A90–£A2050, with superannuation on the F.S.S.U. basis.

Copies of the general conditions of appointment of sub-professorial staff in the University of Adelaide and of a statement for the information of candidates may be had on application to the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1, or to the Registrar. Any further information desired will be supplied on request.

Applications, in duplicate, and giving the information listed in the general conditions of appointment, should reach the Registrar, University of Adelaide, Adelaide, South Australia, not later than November 30, 1958. E8810

REVISED

UNIVERSITY OF NOTTINGHAM

DEPARTMENT OF MECHANICAL ENGINEERING

SENIOR RESEARCH ASSISTANT

Honours graduates in Engineering or Physics are invited to apply for appointment as SENIOR RESEARCH ASSISTANT in the above Department for work on fatigue of metals or experiments in stress analysis. Candidates may read for Higher Degrees. Lecturers' salary scale £900 by £50 to £1300 with membership of Universities Superannuation Scheme and family allowances. Conditions of Appointment and Form of Application, which should be returned by Saturday, 18th October, from the Registrar. E8765

SOUTH-EAST ESSEX TECHNICAL COLLEGE LONGBRIDGE ROAD, DAGENHAM

HEAD OF THE MECHANICAL AND PRODUCTION ENGINEERING DEPARTMENT

Applications are invited for the post of HEAD OF THE MECHANICAL AND PRODUCTION ENGINEERING DEPARTMENT (Grade V). Candidates should have high academic qualifications, together with teaching and industrial experience. The appointment will date from 1st January, 1959, if possible. Persons who applied in response to the earlier advertisements need not re-apply.

Salary: £1900 by £50 to £2050, plus London Allowance.

Application forms and further details (stamped, addressed foolscap envelope) obtainable from the Chief Education Officer, County Offices, Chelmsford. Closing date, 25th October, 1958. E8747

WANDSWORTH TECHNICAL COLLEGE

ASSISTANT GRADE B

Wandsworth Technical College, required, January, 1959, ASSISTANT GRADE "B" for—

(1) Mechanical Engineering subjects, including Applied Thermodynamics.

(2) Mechanical Engineering subjects, including Theory of Structures.

Graduate or equivalent qualifications; industrial and teaching experience desirable.

Burnham F.E. salary scale grade "B" £650 by £25 to £1025, plus London allowance and additions for training and qualifications. Increments within the scale for experience.

Application forms from the Secretary, Wandsworth High Street, S.W.18, to be returned by 25th October, 1958. 1813). E8758

SOUTH WEST METROPOLITAN REGIONAL HOSPITAL BOARD

BOARD'S REGIONAL ENGINEERS DEPARTMENT

APPOINTMENTS

Applications are invited for the following appointments on the permanent staff of the Board's Regional Engineers Department, generally in accordance with Whitley Council conditions of service. Headquarters moving immediately to near Paddington Station.

ENGINEERING ASSISTANTS (MECHANICAL AND ELECTRICAL).—Commencing salary within the scale: (i) £525 (at age 21 or over) by £20 (4) by £25 (5) to £730, for candidates possessing O.N.C. or equivalent; or (ii) £655 (age 23 or over) by £25 (4) by £30 (1) by £35 (4) by £40 (1) to £965, for candidates possessing H.N.C. or equivalent. London Weighting of £20–£40 per annum payable in addition.

DRAUGHTSMEN OR WOMEN.—£415 (at age 21 or over) by £20 (2) by £25 (3) by £35 (1) by £25 (2) to £615 per annum, plus London Weighting.

Applicants should have had suitable training, including 3 years' technical experience in Engineering Drawing. Site or workshop as well as drawing-office experience an advantage.

JUNIORS, MALE OR FEMALE.—£225 (men); £217 (women); at age 17, rising to £425 per annum, plus London Weighting. The work provides an excellent opportunity for a student wishing to acquire technical qualifications in this profession.

Application forms obtainable from the undersigned at 11a, Portland Place, W.1, to be returned completed by not later than 20th October.

E. G. BRAITHWAITE, Secretary. E8742

ATOMIC WEAPONS RESEARCH ESTABLISHMENT

ALDERMASTON, BERKS

ENGINEER

ENGINEER (Basic Grade) required by the Atomic Weapons Research Establishment, Aldermaston, Berks, for duty at Orfordness, Suffolk. To be a member of a team engaged on the engineering design of special missile telemetry equipment to meet difficult environmental conditions.

The work will include supervision of the preparation of drawings, the preparation of specifications and liaison with design offices both in A.W.R.E. and industry.

A recognised engineering apprenticeship and Corporate Membership of a Senior Engineering Institution or equivalent qualifications required.

Some drawing office experience and an up-to-date knowledge of component and material specifications an advantage. Experience in the design of airborne radar and electronic equipment and particularly of the design problems associated with difficult environmental conditions is desirable.

Salary: £815 (at age 25)—£110 (at age 34 or over)—£1270.

Contributory Superannuation Scheme. A house or alternatively substantial assistance in house purchase will become available for married officers living beyond daily travelling distance.

Convenient Assisted Travel Schemes are operating from Felixstowe, Ipswich and Woodbridge.

Postcards for application forms to the Senior Recruitment Officer at A.W.R.E., Aldermaston, Berks. Please quote ref. 2040/25. E8755

CITY OF NOTTINGHAM

WATER DEPARTMENT

CIVIL ENGINEERING ASSISTANT

Applications for this permanent, pensionable appointment are invited from Engineering Graduates with at least 5 years' experience, and should be sent to the Engineer and General Manager, Water Department, Castle Boulevard, Nottingham, by the 20th October next, with the names of two persons to whom reference may be made. Salary according to experience in the Special Grade, £750 by £40 to £1030.

T. J. OWEN,
Town Clerk.
Guildhall,
Nottingham. E8767

Classified Advts. continued on page 104

PUBLIC APPOINTMENTS

STAFFORDSHIRE POTTERIES WATER BOARD

APPOINTMENT OF CIVIL ENGINEERING ASSISTANTS

Applications are invited for the following appointments :—

(1) THREE CIVIL ENGINEERING ASSISTANTS (Temporary), Grade A.P.T. V (£1175 to £1325 p.a.). These appointments are not on the permanent staff, but will be for not less than three years. Applicants must be Corporate Members of the Institution of Civil Engineers and have had experience in the design and construction of at least one of the following :—Pumping stations, filtration plant, reinforced and mass concrete service reservoirs and aqueducts.

(2) CIVIL ENGINEERING ASSISTANT, Grade A.P.T. III (£845 to £1025 p.a.). Applicants should be Corporate Members of the Institution of Civil Engineers and preferably have had experience in the design and construction of waterworks.

The Board will provide housing accommodation for the successful candidates if required.

Reasonable removal expenses will be allowed by the Board.

The appointments are subject to the provisions of the National Scheme of Conditions of Service ; to the provisions of the Local Government Superannuation Act, 1937 ; to termination by one month's notice on either side, and to the successful candidate passing a medical examination.

The Board has considerable major works in hand which are to be completed within the next three to five years. These works include the development of an impounding reservoir scheme with the design and construction of pumping station, filtration plant, aqueducts up to 40in. diameter, and concrete service reservoirs up to 10 million gallons capacity.

Applications, stating age, full details of training, qualifications, present and previous appointments, details of experience, together with copies of two recent testimonials, or the names of two persons to whom reference can be made, and clearly stating for which post they are applying, should be forwarded to the undersigned not later than Monday, 27th October, 1958.

C. V. BROWN,
M.I.C.E., M.I.Mech.E., M.I.W.E.,
Engineer and Manager and Clerk.

Albion Street,
Hanley,
Stoke-on-Trent. E8799

WAR DEPARTMENT

WILTSHIRE

CLERK OF WORKS (MECHANICAL)

CLERK OF WORKS (MECHANICAL) required by War Department in Wiltshire. Applicants must be of British parentage and have O.N.C. in Mechanical Engineering or equivalent, and five years' apprenticeship or equivalent with engineering concern.

Experience : Further three years with an engineering firm, or three years as supervisor of labour, chargehand or technical officer in engineering industry.

Completion of course at S.M.E. is equivalent qualification.

Salary according to age, qualifications and experience, on range of £655 (at age 26) to £820 per annum.

Apply : Chief Engineer, Salisbury Plain District, Bulford Camp, Wilts. E8750

MERSEY DOCKS AND HARBOUR BOARD

SHIPBUILDING DRAUGHTSMAN

Applications are invited for a SHIPBUILDING DRAUGHTSMAN, who should have served a full-time apprenticeship as a Shipbuilding Draughtsman and hold a Higher National Certificate in Naval Architecture.

Candidates should preferably be between 25 and 35 years of age and must have completed their National Service.

Salary will be in accordance with the Board's scale.

Applications should be addressed to the Engineer-in-Chief, Mersey Docks and Harbour Board, and received not later than 14th November, 1958.

A. S. MOUNTFIELD,
General Manager and Secretary.

Dock Office,
Liverpool, 3. E8796

THURROCK URBAN DISTRICT COUNCIL

ENGINEER AND SURVEYOR'S DEPARTMENT

ENGINEERING ASSISTANT

Thurrock U.D.C. (Engineer and Surveyor's Department) require ENGINEERING ASSISTANT. Salary within A.P.T. I/II, i.e. £575–£845 per annum. Candidates should have completed their training in a Municipal or Civil Engineer's Office and have had some subsequent experience. Appointment pensionable.

Applications, stating age, qualifications and experience, and quoting three referees, to the Clerk of the Council, Council Offices, Grays, by 20th October, 1958. Canvassing disqualifies. Relationship with members or Senior Officers of the Council must be disclosed. E8749

PUBLIC APPOINTMENTS

A.E.R.E. HARWELL | **REACTOR SERVICES**

A professional ENGINEER is required to be responsible for the maintenance of several high and low power reactors and their ancillary equipment. Appropriate mechanical, electrical and electronic experience and an Engineering degree desirable.

Salary : £1300–£1740 (Engineer II)—Ref. 1217/25.

ENGINEERS with at least graduateship of a senior engineering institution are required to assist in the prevention, analysis and rectification of electronic failure and to undertake training in reactor maintenance. The main requirement is an ability to establish causes from effects. A degree in light electrical engineering would be an advantage.

Salary : £815–£1270 (Engineer III)—Ref. 1216/25.

An apprenticed or similarly trained TECHNICAL OFFICER is required to be responsible to an engineer for a team engaged in the assembly and construction of electrical control and instrumentation equipment of all types for experimental rings and loops. Appropriate experience and National Certificate or equivalent desirable.

Salary : £875–£1050 (Tech. II)—Ref. 1218/25.

Send POSTCARD to the Group Recruitment Officer, U.K.A.E.A., Atomic Energy Research Establishment, Harwell, Berks, for application form and details, quoting appropriate reference.

E8754

design engineers

In their Nuclear Reactor Projects
the Industrial Group of the

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

are extending the limits of engineering practice in a variety of directions. Despite the large scale and novelty of the work, it is based on accepted engineering design but offers great scope for original contributions.

Previous experience in this field is not essential and initial training will be given. Applicants must be qualified to H.N.C. or degree level in mechanical engineering and be corporate members of a senior engineering institution or equivalent. There are a number of posts on systems design and control aspects suitable to control or electrical engineers, and some opportunities for civil or structural engineers to adapt themselves to this work.

THE SALARIES WILL BE BETWEEN £1,300 - £2,600 p.a.

A number of higher posts may be available with starting salaries of not less than £2,600.

If you are keen to participate in these projects and have good design or project experience, you are invited to write for further particulars of the types of work, and of the engineering design experience appropriate to it, to

Director of Reactor Design,
U.K.A.E.A.
Risley, Warrington, Lancashire

Please mark your postcard or envelope Ref 2673

CLOSING DATE 20th OCTOBER, 1958

UKAEA

E8752

STAFFORDSHIRE POTTERIES WATER BOARD

CLERK OF WORKS

The Board invite applications from suitable candidates for the position of CLERK OF WORKS on the construction of a 2,000,000 gallon reinforced concrete reservoir, an 18in. washout main and other ancillary works, at a salary of £18 per week, plus £3 per week subsistence allowance.

It is estimated that the time required for the completion of the contract will be approximately eighteen months, and at the end of this time it is anticipated that further works will be under construction.

Applications, stating age, full details of experience, accompanied by copies of two recent testimonials, and endorsed "Clerk of Works," must reach the undersigned not later than Monday, 27th October, 1958.

Canvassing in any form will be deemed a disqualification.

C. V. BROWN,
M.I.C.E., M.I.Mech.E., M.I.W.E.,
Engineer and Manager and Clerk.

Albion Street,
Hanley,
Stoke-on-Trent. E8800

TENDERS

ST. AUSTELL RURAL DISTRICT COUNCIL

DISPOSAL OF SURPLUS WATERWORKS PLANT

The undermentioned equipment is offered for sale by TENDER. Further details may be obtained on application to the Engineer and Surveyor at this address and the plant may be inspected at the Council's depot.

1 No. 90 h.p. Metropolitan-Vickers INDUCTION MOTOR 730 r.p.m., 400 volts, 3-phase.

2 No. Sigmund HA3A CENTRIFUGAL PUMPS to discharge 53 g.p.m. cold water against 128ft. head with B.T.H. 5 h.p. single-phase motors.

1 No. B.T.H. MANUAL STARTER, as used with above pumps.

1 No. Wallace & Tiernon type E.R.C. CHLORINE RESIDUAL RECORDER with clockwork recording mechanism.

Tenders in plain, sealed envelopes endorsed "Tender for surplus equipment" for part or all of the items are to be sent to me not later than noon on 30th October, 1958.

The highest or any tender will not necessarily be accepted.

W. MELVILLE MITCHELL,
Clerk to the Council.

"Trevarna," 12, Carlyon Road,
St. Austell. E8783

EDUCATIONAL

UNIVERSITY OF LONDON : A course of five lectures entitled "Information Theory and its Applications to Fundamental Problems in Physics" will be delivered by Professor L. Brillouin at 5.30 p.m. on 21, 23, 24, 27 and 29 October at King's College, Strand, W.C.2. ADMISSION FREE, WITHOUT TICKET.

JAMES HENDERSON,
E8757 E Academic Registrar.

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A BRITISH-MANAGED ENGINEERING GROUP with works in Bihar, India, requires for its Head Office Administrative Staff in Calcutta a GRADUATE ENGINEER (preferably single) in the age group 26–32 who is interested in making a career in India. Candidates who have had training in steel works or at a refractory works would be preferred and subsequent sales experience would be advantageous.—Applicants should state age, experience and whether married or single.—Write Box SE/124 c/o 95, Bishopsgate, London, E.C.2.

E8756 A

A.E.I.–JOHN THOMPSON NUCLEAR ENERGY COMPANY, LTD., RADBROKE HALL, KNUTSFORD, CHESHIRE

GRADUATE MECHANICAL ENGINEERS

Applications are invited from GRADUATE MECHANICAL ENGINEERS for work connected with the assessment of the safety and operating characteristics of nuclear power plants.

Previous experience of general industrial practice or research is essential. Applicants must have a good mathematical background together with an interest in thermodynamics and fluid flow theory. Special qualifications in mathematics will be looked for but need not be essential.

The offices are situated in Knutsford and the Company provides transport from the Stretford/Sale/Altrincham areas and there are first class dining facilities. This position is on the permanent staff and there is a contributory pension scheme in operation.—Application should be made to the Chief Engineer, quoting reference JRMS/JMY.

E8797 A

A GENERAL ENGINEERING COMPANY in the North of England requires a college or University trained GRADUATE in Engineering for their Design and Development Department. Applicants, up to 25 years of age who have completed their National Service, must possess a very definite flair for design and development work. The Company is a progressive one and operates a generous superannuation scheme.—Write giving full particulars of training, experience, age and salary required to BOX No. E8801, "The Engineer."

A

A RETIRED OR FREELANCE DRAUGHTSMAN required to undertake work at home preparing detailed drawings from general layouts. Good general engineering experience essential, preferably with special purpose machinery. Resident London or Home Counties.—Write BOX No. E8773, "The Engineer." A

ASSISTANT WORKS ENGINEER

Applications are invited for this post at an expanding Chemical Plant. The applicant will be required to organise and operate maintenance routines, both mechanical and electrical. He should have a sound workshop experience with a good knowledge of hydraulics and mechanical handling equipment.

Minimum qualifications : Higher National Certificate in Mechanical Engineering, but A.M.I.Mech.E. preferred.

Age range preferred : 30–40 years.

Applications in confidence, giving brief details of positions held, qualifications and salary required, to : The Managing Director, STEETLEY MAGNESITE CO., LTD., Palliser Works, P.O. Box No. 8, Hartlepool, Co. Durham.

E8746 A

B.E.A. REQUIRE A HEATING AND VENTILATING FITTER, with knowledge of pressure jet oil burning boilers and ancillary heating equipment, at their Head Office. Qualifications : Recognised engineering apprenticeship. Rate of pay 4s. 4½d. per hour, plus 8d. per hour bonus, plus proficiency pay. 44-hour week.—Written applications, giving full details, to Personnel Officer, Head Office, BRITISH EUROPEAN AIRWAYS, Keyline House, Ruislip, Middlesex. E8787 A

BRITISH PETROLEUM COMPANY, LTD., has a vacancy for an ENGINEER at its Head Office in London. Applicants aged 30–35 must have a University Degree in Civil Engineering and should hold corporate membership of Institution of Civil Engineers. General experience in construction works with good knowledge of contract procedure is required and some knowledge of mechanical and electrical works is advantageous. The job is a responsible one and consists of arranging contracts of an engineering nature with contractors, consultants and architects. Salary according to age, qualifications and experience, non-contributory Pension fund, assisted house purchase scheme, removal expenses and settling-in allowance payable in certain cases. Luncheon Club.—Write, giving full details, quoting H.4358A, to Box 5854, c/o 191 Gresham House, E.C.2. E8770 A

SITUATIONS VACANT

CEMENT MANUFACTURERS REQUIRE AN ENGINEER to assist in the mechanical and, if possible, civil work associated with the planning for and installation of a very wide range of new plant. The position, which calls for a man of about 30, with initiative, who has had considerable experience of site work, offers distinct possibilities of advancement. Bonus and pension schemes.—Applications, giving age, qualifications, training and experience, should be addressed to : The Area Engineer, A.P.C.M., LTD., Stone Castle, Greenhithe, Kent. E8818 A

DESIGN DRAUGHTSMEN required for mechanical design of nucleonic instruments. Pleasant working conditions. Excellent rates of pay.—Apply : Chief Draughtsman, ISOTOPE DEVELOPMENTS, LTD., Beenham Grange, Aldermaston, Berks. Tel. : Woolhampton 451. E8748 A

DESIGN ENGINEER required to take charge of public company's conveyors design and manufacturing division. Age 30–40. Wide experience essential. Applicants must have the capacity to prepare complete schemes and the ability to secure business based thereon. This is an outstanding opportunity for the right man.—Applicants should give particulars of their age, education and experience together with salary required.—BOX No. E8778 " The Engineer." A

DRAUGHTSMAN/DESIGNER, aged 35/40, with experience in construction of timber water cooling towers and concrete bases, required for North of England. Good salary conditions, and contributory pension scheme. Write.—BOX No. E2114, " The Engineer." A

EDITORIAL POST. YOUNG ENGINEER qualified to become corporate member major engineering institution required to fill editorial post covering light electrical and electronic engineering. Desire to write essential. Age 26 to 30 preferred. Pension and Bonus Schemes. Reply, stating age, particulars of qualifications and experience to date, to : The Editor, "The Engineer," 28, Essex Street, London, W.C.2. E8825 A

ENGINEER REPRESENTATIVE LONDON

An old-established Midlands firm of Structural Engineers requires an ENGINEER to represent them in London and the South.

Qualifications : age 35 to 38, experience in Structural Engineering, able to conduct negotiations, preferably a member of the Institution of Civil or of Structural Engineers, of good personality and address and possessing initiative.

Office accommodation would be provided together with a salary appropriate to the requirements of the post.

Applicants are invited to write, in confidence, to the Managing Director, the LILLESHALL COMPANY, LTD., St. Georges, Oakengates, Shropshire.

E8805 A

ENGINEERING INSURANCE. Applications are invited from Mechanical Engineers not over 35 years of age, who having served an apprenticeship with Crane and Lift Makers have a sound theoretical and practical knowledge of Cranes, Lifts, Lifting Machines and their maintenance, and are qualified to Higher National Certificate standard, for a vacancy as ENGINEER SURVEYOR in the West Country. The position is permanent, pensionable, with salary scale of £735 rising to £1060 per annum, plus expenses and allowances.—Apply in own handwriting to BOX No. E8776, " The Engineer." A

EXPERIENCED HEATING AND VENTILATING ENGINEER required by Contractors in Westminster. Applicants must be experienced in the preparation of drawings and estimates. Interesting position for right man with go-ahead firm. 5-day week, luncheon vouchers, non-contributory pension scheme. Applications.—BOX No. E2115, " The Engineer." A

FIRST-CLASS DESIGNER REQUIRED for shot-blasting machinery. Good salary and excellent prospects for the right man.—Write BOX 352, Dorland Advertising, Ltd., 18-20, Regent Street, S.W.1. E8777 A

FIRST-CLASS ENGINEER required immediately to train and take charge, in early 1960, of member firm of large group, employing approximately 150 personnel engaged in manufacture of winding, hauling and steel works plant. Excellent opportunity for applicant having skilled engineering training with a flair for commercial and general administration ; age 35/40. Write, giving fullest details respecting qualifications, experience, age and salary required.—BOX No. E2113, " The Engineer." A

GRADUATE RESEARCH ENGINEERS

DAVY AND UNITED ENGINEERING CO., LTD. engaged in manufacturing all types of equipment for the Steel Rolling Industry, require GRADUATE ENGINEERS to join an expanding research department. Applicants should have completed National Service and preferably have had a few years experience in engineering. Salary commensurate with experience and qualifications.

Good conditions, Dining, Welfare and Sports facilities. Contributory pension scheme.

Apply in writing to :

Personnel Department, Davy and United Engineering Co., Ltd., Darnall Works, Sheffield, 9.

E8738 A

JOHN SMITH'S TADCASTER BREWERY COMPANY, LTD., The Brewery, Tadcaster, Yorkshire, require a FIRST ASSISTANT to the Chief Engineer. Applicants should be of University degree or recognised institution standard in mechanical engineering. Age not exceeding 35 years. Attractive commencing salary and pension scheme. House available if required.—Applications stating age, married or single, experience and qualifications to be addressed to the Engineering Director. E8806 A

LARGE FIRM OF DAIRY AND MILK PRODUCT MANUFACTURERS require for Executive Position, ELECTRICAL MAINTENANCE ENGINEER, mechanical knowledge essential. Must be capable of handling fairly large installations.—Write, with full details, experience, etc., to : INDEPENDENT MILK SUPPLIES, LTD., Rossmore Road, Marylebone, N.W.1. E8760 A

LIFTING AND MECHANICAL HANDLING

An old-established company with offices in West London have a vacancy for a

TECHNICAL ASSISTANT

for Inside Sales work.

The post offers excellent prospects of advancement for a young man with some experience and an engineering background.

Write, giving details of age and qualifications, —BOX No. E8795, " The Engineer." A

LUBRICATION ENGINEER required by lubrication equipment engineers. Location London, N.18. Lubrication knowledge an advantage, but not essential if good practical and technical background. Excellent prospects. Apply in confidence.—BOX No. E2127, " The Engineer." A

MAJOR PETROLEUM COMPANY requires a SENIOR PIPELINE/PUMPING ENGINEER in the age group 38–45 for work in their London office. Applicants should have a good working knowlege of pipeline/pumping hydraulics and a broad experience in designing, construction, operating and maintaining pipelines and pumping stations. The work would involve the operation and maintenance in this country of a network of high-pressure oil pipelines with anti-corrosion work, including cathodic protection, but engineers with the necessary qualifications and experience in gas or water pipelines would be considered. Starting salary commensurate with qualifications and experience. Excellent Pension Scheme. Apply, giving full details of qualifications, age and experience to BOX No. E8802, " The Engineer." Replies can only be sent to those selected for interview. A

OLD-ESTABLISHED FIRM of Mechanical Engineers in the West of England engaged on all types of heavy mechanical handling plant and constantly expanding, require qualified MECHANICAL ENGINEERS able to take charge of Contracts in the Drawing Office. Superannuation scheme and good canteen facilities are available.—Please write in the first instance, giving full particulars of qualifications, experience, level of remuneration desired, to : The Chief Draughtsman, STRACHAN AND HENSHAW, LTD., Victoria Road, St. Philip's, Bristol, 2. E2120 A

POLLARD BEARINGS, LTD.,
FERRYBRIDGE, KNOTTINGLEY,
YORKSHIRE

TECHNICAL SALES ENGINEERS

Applications are invited from suitably qualified technicians for the above posts, which offer wide scope for initiative in furthering the application and sale of Ball and Roller Bearings. Successful applicants would be required to give advice and make recommendations direct to customers.

H.N.C. standard and previous experience in the Ball and Roller Bearing Industry desirable but not essential.—State full details of experience, age and remuneration expected. Address replies to General Manager, marked " Confidential."

E8762 A

SALES ENGINEER required, to develop sales of Machine Tool Control equipment, having established contacts with Machine Tool manufacturers, distributors or users, electrical background an advantage.—Write, giving details of experience, age and salary required, to Personnel Manager, EKCO ELECTRONICS LTD., Southend-on-Sea. E8790 A

PROJECT ENGINEER

required for the Development Section of a group of lifting gear manufacturers. Preference given to a University Graduate with knowledge of modern structural design and some practical experience of crane bridge manufacture. Age 26–30. A permanent, progressive and pensionable position is offered to a suitable man with creative ability.—Apply to the Director, De Bergue Machine Tools, Ltd., Development Section, Mary Street, Manchester, 3. E2126 A

SENIOR SALESMAN required by precision engineering company in the Midlands area manufacturing hydraulic equipment and small component parts for machine tool and allied trades. Good education essential. Contributory pension scheme available. Apply in writing, giving full details of training, experience and salary required.—BOX No. E2112, " The Engineer." A

SENIOR SERVICES DRAUGHTSMAN required with experience of Factory services for water, gas, oil and air ; pump installations and pipe layouts. —Write or telephone to Chief Draughtsman, General Engineering Dept., Northern Aluminium Company, Ltd., Rogerstone, Mon. Telephone : Newport 59991/6. E8814 A

SUPERINTENDENT ENGINEER with experience maintenance refrigeration and factory equipment and preferably knowledge building maintenance required by British Company in South American plant. Passages paid and regular leaves in U.K. Good prospects for engineer of education and experience.—Write, giving details of age and experience to BOX No. E8769, " The Engineer." A

THE SERVICES OF AN ASSISTANT ENGINEER are required in connection with Oil Refinery Maintenance. His immediate duties will relate to Inspection and Preventive Maintenance ; applicants should therefore have had experience of this work in Chemical Works or Refineries. The commencing salary will depend upon experience and qualifications. The successful applicant must be a corporate member of a professional engineering institution.—Applications should be addressed to the Refinery Manager, LOBITOS OILFIELDS, LTD., Ellesmere Port, Cheshire. E8781 A

VENTILATION ENGINEER. A public company is engaged in the formation of a division to manufacture and instal extractor fans and all forms of ventilating equipment. In this connection the Company seeks an experienced engineer able to direct the new division in its approach to the industrial and domestic fields. Age 30–35.—Write in first instance giving particulars of age, education and experience together with salary required to BOX No. E8779, " The Engineer." A

VICKERS-ARMSTRONGS (ENGINEERS), LTD., require a SENIOR TECHNICAL ENGINEER at their Southampton Office for design calculations in connection with the application of nuclear power to marine propulsion. Applicants should have a Degree or similar qualification in mechanical engineering and marine experience. Salary will be in accordance with age, qualifications and experience, and the appointment is subject to membership of the Company's Superannuation Scheme.—Applications should be in writing to the Manager, VICKERS-ARMSTRONGS (ENGINEERS), LTD., Oak Yard, Hazel Road, Itchen, Southampton. E8782 A

WORKS MANAGER

A progressive, expanding manufacturing organisation in South Yorkshire wishes to appoint a WORKS MANAGER for its well equipped plant, which employs 800 personnel. Candidates should have considerable experience of factory management in the field of precision turning, grinding and assembly. This appointment carries a very attractive salary together with excellent conditions of service, and the successful candidate will be a member of the top management team, and responsible to the General Manager.—Please reply, giving full details of age, present salary, experience and qualifications, which will be treated in the strictest confidence, to the General Manager, BOX No. E8761, " The Engineer." A

£2,000,000. We have been spending this sum annually on new plant and equipment, and our budget is now still higher. Since we design and erect our own plant, we must recruit ENGINEERS and DRAUGHTSMEN of all types to meet this programme. We pay good salaries, and the Headquarters are pleasantly situated near London.—Apply briefly to BOX No. E8594, " The Engineer," quoting Ref. P.E.D. 1. A

THE LUMMUS COMPANY LIMITED
IMPERIAL HOUSE,
80, REGENT STREET,
LONDON, W.1.

Engineers and Constructors for Industry require a

PUMP ENGINEER

for work in their London office, preferably with experience of refinery pumps and compressors. Work will entail preparing specifications and checking quotations and drawings. Finest working conditions. One minute from Piccadilly Circus. Five-day week. Sickness and pension schemes.

Apply by letter to the Personnel Officer, or telephone Regent 4030 for an interview.

E8745 A

Classified Advts. continued on page 106

BOOKS and PUBLICATIONS

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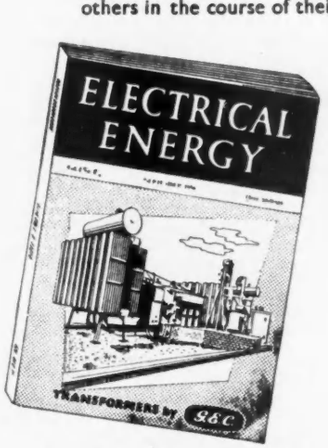

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SITUATIONS VACANT

MSL have been retained to advise on the appointment of a

SALES MANAGER

for a medium-sized engineering company engaged in the design and manufacture of valves for the control of fluids and gases.

The Sales Manager will be responsible for planning and control of the distributive organisation, for supervision of salesmen and agents, and for co-operating in new product development. He will also promote sales by personal approach to users in the Marine and Land installations, petroleum and chemical industries.

Candidates must have 5 years' technical sales experience with management responsibility and knowledge of valve control of low and high pressure steam, fluids and gases. A degree or professional qualification in mechanical engineering is essential.

Preferred age 35 to 40. Initial salary about £2,250: with contributory pension, life assurance, car and expenses. Some overseas travel may be required.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1242, to J. G. Smith.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E140 A

SITUATIONS VACANT

MSL have been retained to advise on the appointment of a

DESIGN & DEVELOPMENT ENGINEER

for a small company located in a rural area in the Severn valley. The company makes components for the motor industry.

The Design and Development Engineer will work on a number of products concerned with i/c engines and may be required to carry out research on manifolds and silencers as well as being responsible for detailed design work. The precise nature of his responsibilities will be established when he assists the Managing Director to draw up a programme for the technical development of the company's products as a basis for the consolidation and expansion of its activities.

Candidates should have a degree or professional qualification in engineering, and have some knowledge of acoustics, electronics, and instrumentation. Experience of design and development work in i/c engines particularly on problems related to "breathing" would be valuable. Age probably 28–35.

Starting salary will probably be between £1,000 and £1,500. House available. Pension. Life Insurance.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1157, to T. E. Watson.

MANAGEMENT SELECTION LIMITED
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E134 A

SITUATIONS VACANT

A Company in the West London area invite applications for the post of

PLANT ENGINEER

for a large factory operating on continuous processes, and who will in due course take over the duties of Assistant Chief Engineer.

Preferred age between 32 and 38, with experience all classes maintenance work, plant installations and steam and electrical generation, together with the distribution of these and other process services.

Applicants should be Graduate Engineers or possess H.N.C., or have equivalent technical and educational qualifications and have served an apprenticeship. Some drawing-office experience and knowledge of machine shop practice also desirable. This is a senior, progressive and well-paid appointment with a good Company and qualifies for contributory staff pension and Insurance benefits. Apply, stating age, qualifications and positions held.—BOX No. E8771, "The Engineer."

A

SITUATIONS VACANT

TWO MECHANICAL ENGINEERS

required in established Development Dept., handling design and installation of a wide variety of plants for carbon black manufacture. Experience of this particular industry not required.

These appointments will be attractive to engineers seeking opportunities to accept responsibility and obtain advancement with a young and expanding company.

Applicants should have a sound basic practical and theoretical training, hold a Degree or equivalent qualifications and be capable of taking part in a wide variety of plant and engineering projects.

Commencing salary in range £1100–£1300 p.a.

Apply, stating age, experience, qualifications, to:

PHILBLACK LIMITED,
Avonmouth Docks Estate,
Avonmouth,
Bristol.

For the attention of the Works Engineer.

E8708 A

SENIOR MECHANICAL ENGINEER

Applications are invited for this appointment, which carries responsibility for the direction and control of a group of engineers and designers engaged in the specification, design and test of rotary and reciprocating pumps, high pressure compressors and turbines.

The designs are complementary to large-scale plant installations under home and overseas design and construction contracts. The post is based in London and offers the opportunity of an excellent salary and a most interesting range of work. An Engineering Degree or membership of the Institution of Mechanical Engineers is essential.

HOUSING assistance is available if required.

Applications, giving full details of qualifications and experience, to :—

The Personnel Manager (Ref. GH/19),
BRITISH OXYGEN ENGINEERING LIMITED,
Angel Road, Edmonton, London, N.18.

E8789A

MECHANICAL ENGINEERS
THE DUNLOP RUBBER COMPANY LIMITED

. . . has openings for MECHANICAL ENGINEERS, with degrees from British universities, who wish to make a career in a steadily expanding organisation with extensive interests, both in the United Kingdom and overseas :

(a) Graduates who have still to undergo practical training will be considered for a two-year postgraduate apprenticeship. The training will include practical workshop experience and the completion of a project. The course provides the practical training required for professional qualifications.

(b) For those who have recently completed their practical training, a number of openings are available which will enable graduates to gain a wide experience in various aspects of engineering with a view to eventual management responsibility.

Those interested should apply for further information and/or an interview, giving details of age, education and experience (if any). Please write to the Engineering Staff Personnel Officer, DUNLOP RUBBER COMPANY, LTD., 55–56, St. James's Street, London, S.W.1

E8759 A

DEVELOPMENT ENGINEERS
to undertake interesting projects on
ANAESTHETIC EQUIPMENT & RESPIRATORY APPARATUS
are required by
BRITISH OXYGEN GASES LIMITED
at their
HARLOW (ESSEX) ESTABLISHMENT

Applications are invited from qualified PHYSICISTS and ENGINEERS capable of handling development projects on their own initiative in collaboration with authorities in the medical field.

The work of the Establishment is concerned primarily with the development and manufacture of gaseous anaesthetic equipment and machines, as well as apparatus for assisting respiration. The positions afford ample scope for inventiveness and originality in an exceedingly interesting field of activity directly connected with human welfare.

Housing is available at Harlow and salaries and conditions are excellent.

Applications to: **Personnel Manager (Ref. GH/20),**
BRITISH OXYGEN GASES LIMITED,
Edmonton Works, Angel Road, Edmonton, London, N.18.

E8788 A

CORROSION ENGINEERS
required by
MAJOR OIL COMPANY
for service in
VENEZUELA

Graduate or equivalent qualification. The work is mainly in connection with Cathodic Protection, of which the candidate should have had several years' practical experience, but a background of more general knowledge of Corrosion is also desirable. Candidates must be able and willing to take responsibility and to assist in the general planning and administration of Co-Ordinated Corrosion Control Programme, covering all aspects of Oil Production, Storage and Transport.

The positions for which candidates of approximately 25/35 years of age will be considered are pensionable age 53. Tours of two years' duration with paid leave in U.K. each tour. First-class passage provided for family, including children up to 18 years of age. Company schooling provided, together with adequate medical care. Knowledge of Spanish advantageous, but not essential, although working knowledge at end of first tour would be expected. Commencing salary according to qualifications and experience.

Please write giving full details age, qualifications, experience, marital status to

BOX Z.T.754,
DEACONS ADVERTISING,
36, LEADENHALL STREET,
LONDON, E.C.3.

E8784 A

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and
DESIGN DRAUGHTSMEN
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MECHANICAL ENGINEERING

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ELECTRICAL ENGINEERING

3. Department of New Development. For design of electrical equipment. Applicants must have a thorough knowledge of distribution and good Drawing Office experience.

Five-day week. Good welfare, canteen and recreational facilities. Superannuation and Life Assurance Schemes. Staff Hostel for single men. Excellent housing prospects. Good salaries based on experience and qualifications.

Applications will be treated as confidential, and should give age, details of qualifications, experience, salary required, department to which application refers. They should be addressed to :

Manager/Personnel,
STEWARTS AND LLOYDS, LIMITED,
Corby, Northants.

E135 A

SITUATIONS VACANT

ENGINEERING IN NYLON

Applications are invited from Corporate and Graduate Members of the Institutions of Mechanical and Electrical Engineers, who are interested in Research, Experimentation and Development.

This work covers a field which includes Machine Dynamics, Heat Transfer, Servo Control Systems, Electronic Circuit Design, Analogue Simulations and Stress problems.

Each Engineer must be capable of undertaking a variety of problems. He should, therefore, have good academic qualifications and real feeling for this type of work.

These are permanent appointments which will offer good opportunities. Rented houses may be made available and assistance is given with removal expenses.

Applications, quoting 113, which will be treated in confidence, should be addressed to:

The Personnel Manager,
BRITISH NYLON SPINNERS LIMITED,
Pontypool, Monmouthshire.

E8807 A

CARBIDE INDUSTRIES LIMITED

A unit of

THE CHEMICALS DIVISION OF THE BRITISH OXYGEN GROUP OF COMPANIES,

invite applications for the position of

CHIEF ENGINEER

at their factory which is under construction at Londonderry, Northern Ireland. This factory will produce Carbide and Acetylene and is adjacent to the Du Pont factory which will produce Neoprene.

The Chief Engineer will be responsible for:

(a) Maintenance of all plant.
(b) Capital and maintenance budgets.
(c) New construction as required after factory completion.

Applicants should have an Honours Degree in Engineering and be Corporate Members of one or more of the professional institutes. Experience in the Chemical, Petroleum or similar process industries is essential. Age 35/45.

This is an interesting, progressive position, offering excellent prospects to a man possessing the necessary ability, enthusiasm and energy.

The salary will be appropriate to qualifications, age, experience and the responsibilities involved. There is a company pension scheme and assistance will be given towards housing and removal expenses.

Apply in writing to :—

Staff Officer,
THE BRITISH OXYGEN COMPANY LTD.,
Bridgewater House, Cleveland Row,
St. James's, London, S.W.1.

E8808 A

A CIVIL ENGINEER

is required for a senior and responsible post in connection with a large development programme at a major works in the Midlands. This programme will take several years to complete.

Extensive civil engineering design experience is essential, and must include a wide knowledge of survey and of heavy foundation work.

Applications will be treated as confidential and should give full details of qualifications and experience.

Write BOX No. E8775, "The Engineer." A

SITUATIONS WANTED

CHIEF DESIGNER, age 40, A.M.I.Prod.E., desires change. First-class practical experience. Accustomed to originate design of jigs, tools and special-purpose machines. Comprehensive knowledge of transfer machines, and production planning.—BOX No. E2128, "The Engineer." B

INTERESTING POST SOUGHT—13 years D.O. Material handling. Experience running office. H.N.C. Structures. 37 years of age. Car owner.—BOX No. E2129, "The Engineer." B

CANADIAN PROFESSIONAL ENGINEER, A.M.I.Mech.E., A.F.R.Ae.S., presently chief engineer Canadian light engineering plant employing 700, offers services to British engineering company desiring to establish in Canada. Educated in U.K., widely travelled, Europe and North America, capable administrator, experienced in top level negotiations.—BOX No. E2125, "The Engineer." B

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E8764 G

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2500kW., 440/3/50, 4-wire PASS-OUT CONDENSING STEAM TURBO-ALTERNATOR SET by B.T.H., steam pressure 255 p.s.i.g., 630 deg. F. temp. suitable for pass-out up to 55,000 lb./hr. between 18/35 p.s.i.g. ; can operate fully condensing.
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E8793 G

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3000kW 6600 volts 3-phase 50 cycles METROPOLITAN-VICKERS Pass-Out/Condensing Steam Turbo Alternator Set, date 1948, designed for 340 p.s.i.g. initially, 600 deg. F. temperature, also suitable for the following duties :

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3000	60,000	40
1800	40,000	110
	double P/out at 1000 kW fully condensing	110 and 40

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1500kW 3300 volts 3-phase 50 cycles by BELLISS & MORCOM, geared set 140/180 p.s.i., 500 deg. F., with jet condenser and accessories.
1000kW 3300 volts 3-phase 50 cycles, by BELLISS & MORCOM, geared set, 115/180 p.s.i., 550 deg. F., with jet condenser and accessories.

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with two tables (one of them swivelling) ; auto down feed to tool head.

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E8753 G

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E111 G

Classified Advts. continued on page 108

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E8774 G

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40-ton Adamson, standard cab control, 42ft. 3in. span, 400/3/50.

30-ton Vaughan, 42ft. 3in. span, almost new.

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E120 G

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E208 G

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410J/492 E221 G

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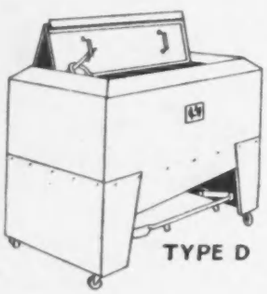

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Type D. PARAFFIN PRESSURE CLEANSING TANK. A semi-rotary pump operated by a treadle, sprays paraffin on parts to be cleaned. Used paraffin returned to pump through patent filter. In two sizes.

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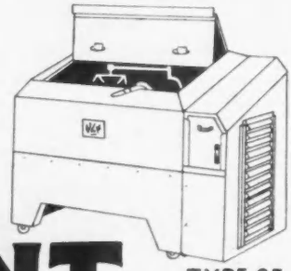
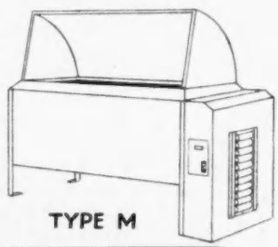


TYPE 2E



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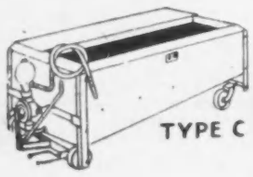

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ATMOSPHERIC WATER COOLING TOWER, capacity 5,000 gal. hr., 101 deg. to 76 deg., wet bulb 60 deg.

TWO TYPE 3C LOW TEMPERATURE STAINLESS STEEL EVAPORATORS by Aperiels Lemale of Paris, capacity approx. 440 gal. hr., complete with air ejector Condenser, Water Tank and Extractor Pump suitable 10 lb. per sq. in. steam pressure and 30in. vacuum, concentration 2 : 1, air ejector condenser driven by 30 h.p. slip-ring induction motor 400/3/50 1460 r.p.m. on C.I. baseplate, calandria fitted 2in. o.d. stainless steel tubes.

600 gal. STAINLESS STEEL JACKETED MIXER, with dished bottom approx. 5ft. 6in. diam. by 4ft. 6in. deep, mild steel welded jacket to within approx. 10in. of top, and fitted direct gear motor driven stainless steel agitator with footstep bearing, approx. 2in. bottom outlet, mixer complete with two stainless steel half-covers with lifting handles and all necessary fittings.

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200 AIR RECEIVERS, stocked up to 9ft. dia., 100 to 500 lb. pressure.

ELECTRIC MOTORS.—150 Totally Enclosed and Flameproof Motors up to 100 h.p.

CRANES.—Mobile 10-ton Lorain, lorry mounted, 30ft.–70ft. extendable jib; 6-ton and 4-ton Coles Diesel-Electric; 3-ton Jones Super 40 (3); Neals 2-ton Diesel, 20ft. jibs (2); Derrick, 10-ton Henderson Steam, 120ft. jib; 5-ton Wilson Electric, 70ft. jib; Steam Loco, 18-ton Brownhoist, 50ft. jib; 10-ton Coles, 40ft. jib; 8-ton Wilson, 35ft. jib; 5-ton Smith, 50ft. jib; 5-ton Cowans Sheldon, 50ft. jib; 5-ton Grafton, 38ft. jib; E.O.T. 40-ton Adamson, 42ft. span; 20-ton Vaughan, 42ft. span (8); Goliath, 40ft. span, 60-ton Clyde, 40-ton Babcock, 10-ton Morris; 5-ton Henderson, 24ft. 7½in. span, 1946; 5-ton King, 29ft. 3in. span; 2-ton Morris, 18ft. span, 2-ton Smith, 34ft. span.

LOCOS.—Fowler Diesel, 150 h.p. (2); Ruston Diesel, 80/88 h.p., new 1942; Hunslet 0–6–0, 18in. by 26in., new 1944; Bagnall 14in. by 22in., two oil fired, one coal; Peckett Steam, 7in. by 12in., 1941; also 3 miles track, 24in. gauge Bogies, Turnouts, &c.

STEEL PIPING.—50,000ft., 2in. Galvanised, new; 60,000ft., 3in. black new; 5000ft., 8in. seamless; 1000ft., 12in. seamless; 500ft., 14in. seamless; 400ft., 18in. riveted; 280ft., 21in. o.d. welded flanged; 3800ft., 21in. seamless flanged; 500ft., 24in. riveted; 1450ft., 27in. o.d. welded flanged; 216ft., 48in. riveted; 216ft., 60in. riveted.

CAST IRON PIPES.—Large stocks all sizes up to 24in. flanged and s.s. Immediate delivery.

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STORAGE TANKS.—300 cylindrical and rectangular up to 12,000 gallons, for oil and petrol, also sectional steel and cast iron up to 50,000 gallons.

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NISSEN TYPE HUTS for sale. Prompt despatch of 16ft., 24ft. and 30ft. wide huts; also "Romney" Huts, 35ft. wide, and "Blister" Hangars, 86ft. 6in. and 91ft. wide. These buildings are in various lengths and comprise steel framework with galvanised corrugated steel sheeting.—Full details from Dept. 115, J. Thorn and Sons, Ltd., Brampton Road, Bexleyheath, Kent (Tel., Bexleyheath 305). E113 G

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NOTE.—The Industrial Works at Dundee will be offered for SALE BY AUCTION at The Royal Hotel, Dundee, on TUESDAY, 4th NOVEMBER, 1958, at ELEVEN A.M.

Catalogues (when ready), price 6d each, may be obtained of Messrs. Henry Butcher and Co., Auctioneers, Valuers and Surveyors of Factories, Plant and Equipment, 73, Chancery Lane, London, W.C.2. Telephone : HOLborn 8411 (8 lines). E8817 J

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IN LOTS.

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GOVERNMENT SURPLUS STORES

SALES BY AUCTION

		Main Location	*Auctioneers*
October 14–15	Vehicles and miscellaneous stores.	Central Ordnance Depot, Bicester, Oxon.	MIDLAND MARTS, LTD. (Dept. L), Market Square, Bicester, Oxon. (Tel. : 73.)
October 21–23	Machine tools, vehicles and miscellaneous stores including :—	M.O.S. Storage Depot, Royal Arsenal, Woolwich, S.E.18.	FULLER, HORSEY, SONS & CASSELL, (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel. : Royal 4861.)

Machine tools, Morris, Ford and Bedford trucks and tractors, passenger cars, trailers, 5-ton standard gauge steam travelling and locomotive cranes, 4 diesel and petrol road rollers 8 to 8½ tons, fork lift and industrial trucks, 220 tons locomotive and tender spares, workshop cranes and garage jacks, diesel electric generating and charging sets, radio and electric stores and equipment, prismatic binoculars and compasses, 5,000 blankets, 4,500 jersey pullovers, 70,000 khaki drill and olive green trousers, shorts and jackets, 16,000 kitbags, 60 tons scrap linen, rags, etc.

October 29–30	Miscellaneous stores, including clothing, canteen equipment, hutting, etc.	Northern Command, Ordnance Sub Depot, Barlow, Nr. Selby, Yorkshire.	BARTLE & SONS (Dept. L), 50–52, Merrion Street, Leeds, 2. (Tel. : 2.0898.)
November 5–6	Machine tools and miscellaneous stores.	Technical Stores Depot, Old Dalby, Melton Mowbray, Leics. (Sale at Melton Mowbray.)	SHOULER & SON (Dept. L), 1, Norman Street, Melton Mowbray, Leics. (Tel. : 81.)

SALE BY TENDER

Approximately 185 short tons of magnesium powder lying at various locations.

Tenders must be submitted by October 24.

(a) *Catalogues* for the above auction sales 1s. 0d. each (P.O's only) obtainable *only* from the auctioneers shown above.

(b) Applications for Tender Forms, should be made to the Ministry of Supply, Directorate of Disposals, First Avenue House, High Holborn, London, W.C.1.

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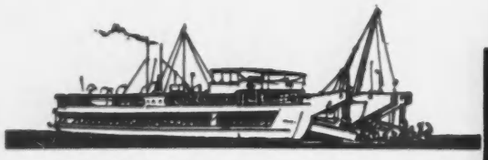

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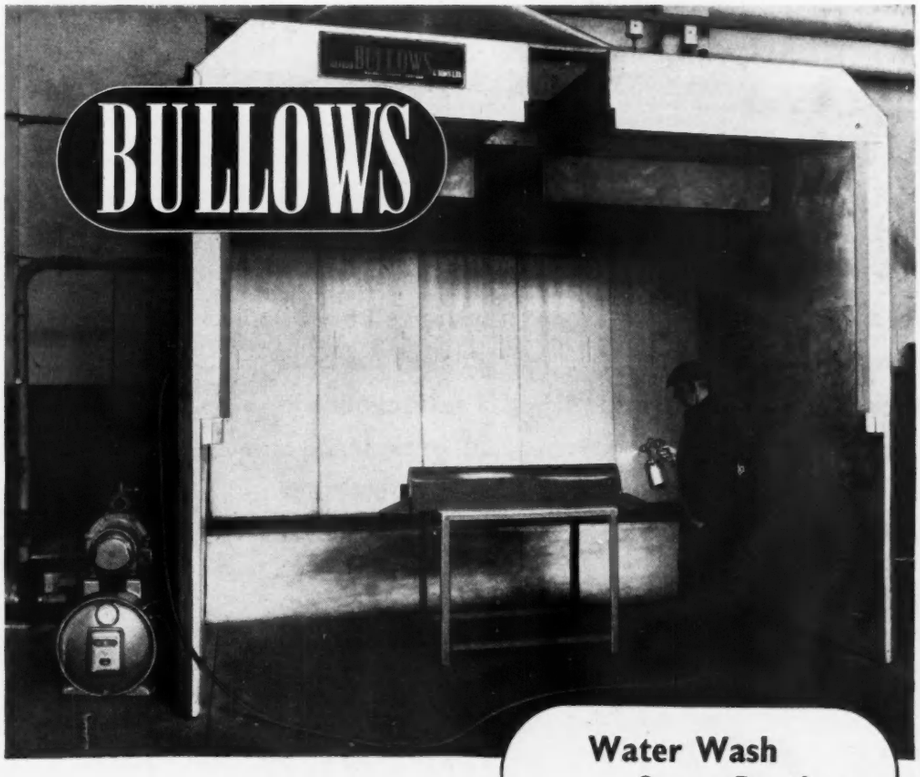

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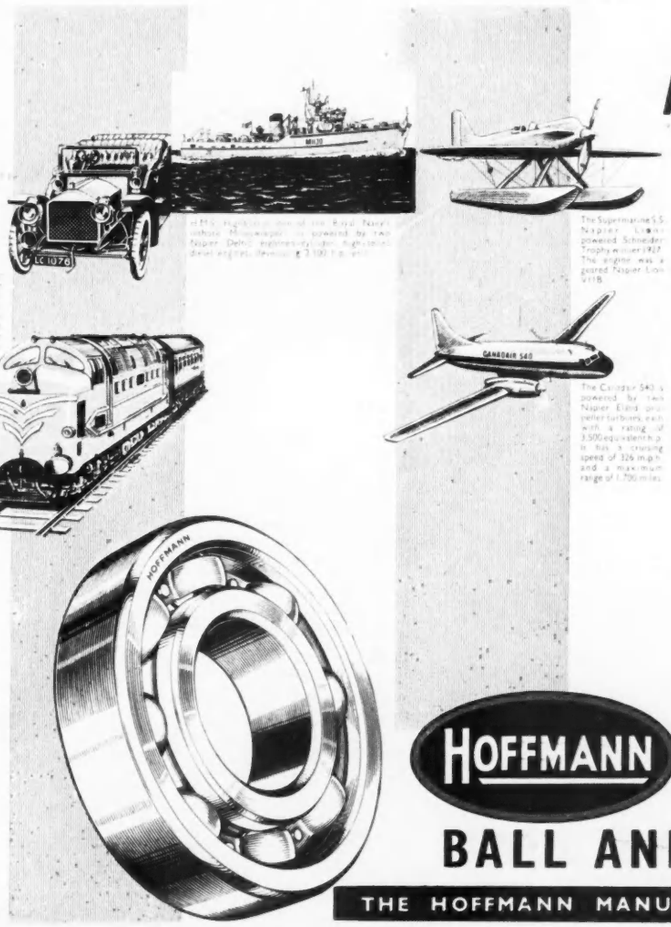

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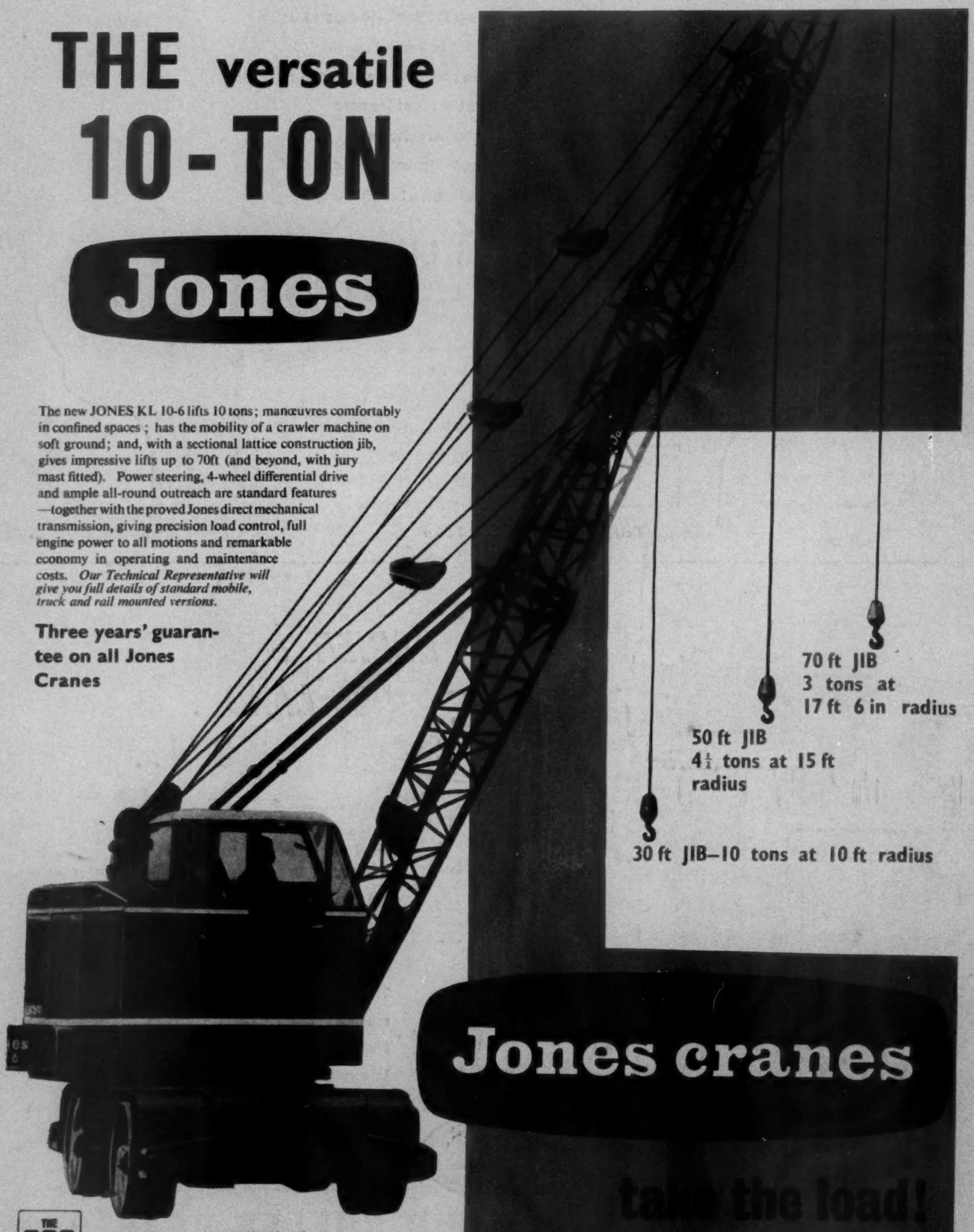

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